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The Welsh Engineers' and Founders' Association

The Foundry Trades' Equipment and Supplies Association

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Other Countries—Other Ways

Reactions to war conditions vary very considerably in the countries of the combatants, and it may be helpful to draw a few comparisons between those operating in the States and here. First of all, we have received the impression that reaction to censorship is taken more seriously in this country, in spite of occasional lapses by the more sensational Press. This, coupled with the silence imposed upon the senior civil servants, tends to create an estrangement between Government departments and industry. In America, the various controllers and directors often address meetings of businessmen to give them the "low-down" on the impact of new legislation upon the conduct of their affairs. Here such officials prepare notes for the Minister to use at a public function. Thus in Great Britain there is a lack of intimacy between the Ministries and industry which does not exist in the U.S.A. The whole structure of their control is laid bare to the public, down to the names of minor officials, the number on their office door, and telephone extension numbers. This obviously invites co-operation with the industrialists. Until recently, dozens of pages of the business newspapers were taken up with the listing of army, navy and air force contracts, but rightly to our mind this feature has now been suppressed. A commendable British method, which effects the same purpose as the addressing of a meeting of a trade association by a "controller" or "director" upon the impact of new Orders, is that recently devised by the British Ironfounders' Association. It has sent to all its members cards which crystallise and explain all the Orders appertaining to the selling of castings.

It is not only the fighting services which seem anxious to co-operate with industry, but also the Home Office, for we notice that most of the Branches of the American Foundrymen's Association have had talks from high officials of the Federal Bureau of Investigation on the subject of combating sabotage.

Since the last war, British firms have justly been proud to announce that they were registered as being on the King's Roll, which for the benefit of our overseas readers means that they employed a fixed percentage of maimed ex-service men. For this war, the United States Navy has sponsored a system involving the award of a pennant carrying a large E to firms which have rendered them outstanding service. The employees of such have the right to wear in the lapel of their coats a button bearing the Navy insignia in recognition of the part they have played in making the award possible. The latest news we have is that 44 firms, including three foundries, have received this much coveted award. This award is known as the Navy E, and is the symbol of efficiency, excellency and achievement. Yet, we could not recommend its adoption in this country, without serious modification, as the flying of such an emblem would counteract the efforts made to camouflage key plants, but something more than a "controlled establishment" would make an appeal to the popular mind. For instance, the ratio of savings to wages might be officially acknowledged.

It has been found desirable in the States to call district meetings, at which were represented the Government buying departments, the main contractors, and small scale manufacturers. On these occasions samples of components were exhibited, and without loss of time discussions were opened as the possibility of quick delivery. Here we have had the formal exhibit of components in various districts, but without that close personal contact which seems to be such a feature of American business methods.

The net result, to our mind, based on observations of the methods employed by the two countries, is that in America a little too much statistical and other important information is too freely released, while here possibly overprecaution is practised. This is due as much to the natural reticence of the average civil servant as it is to the proximity of the enemy. On the other hand, in America, the war theatres still being very distant, coupled with a well-founded belief in the immensity of their own natural resources, the average citizen sees but little logic in hiding figures, which, he feels, if published, can only, if viewed correctly, disturb the enemy's equilibrium. Typical of such an attitude is the statement of an executive of a Detroit steel foundry to the effect that his concern has increased its output from a potential maximum of 9,600 to an achieved output of 17,000 tons. A parallel statement in this country would be that the Institute of British Foundrymen has been responsible for erecting x new steel foundries, x − 1 of which are now in full operation, having a total potential monthly output of y tons, with an achieved output z tons. Therein lies the difference, but happily results are similar.

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Notes from the Branches

East Anglian Section.—The annual general meeting was held in the Lecture Hall of the Central Library, Ipswich, on March 21. The President, Mr. Geo. Hall, occupied the chair. Apologies for absence were received from Mr. C. H. Kain, Mr. H. H. Shepherd, Mr. L. Tibbenham and Mr. J. King.

Annual Report

Mr. J. L. Francis presented the following annual report:—

During the period under review the Institute has passed through another 12 months of war conditions and restrictions. On the whole, their hampering effect has not been more pronounced than for the first year. In some respects it has been less, because members have now become accustomed to the altered times of the meetings and other necessary modifications to the usual procedure.

So far as the East Anglian Section is concerned, a full programme has been carried out, again making use of Saturday afternoons during the spring and summer months. The programme began in March and finished in September, comprising five lectures, a social gathering and a works visit. A notable feature lies in the fact that all the lectures for the session were prepared and delivered by members of the East Anglian Section.

Membership of the Section is now 60, with one member firm. The change is accounted for by the addition of one, the resignation of two and the transference to other Branches of two, making a reduction of three in the total.

Mention must be made here of an entirely new activity undertaken by the Section during the past year. Towards the end of the summer the Principal of the Ipswich School of Engineering approached this Section with a view to the inauguration of a course in "Foundry Technical Education for Patternmakers and Foundrymen." This resulted in the formation of a Foundry Technical Education Advisory Committee, made up of ten representatives, seven being members of the Institute. This Committee has met three times.

Arising from the work of the Committee, in co-operation with the Principal of the School of Engineering, two courses have been arranged, one for foundrymen and the other for patternmakers. Both occupy two sessions per week and cater for both practical and theoretical instruction. It is intended that each course shall follow the syllabus of the City and Guilds of London Institute, and in the case of the foundry course extend over a period of three years. The practical work for this course is to be done on Saturday mornings. Instructors for each course have been appointed, and whilst the patternmakers' course will not commence until September, the foundry course is already under way.

A place suitable for instruction in the practical side of foundry work was found in the School of Engineering basement, providing some slight structural alterations were made, and these have now been done. Some equipment was, of course, necessary, and in this matter the Committee found ready help and generosity. For a nominal sum a small coke-fired crucible melting furnace was obtained, whilst a core-drying oven was given entirely free; also, one firm in the area made a donation of £50. Other requirements, such as sand, moulding flasks, etc., have been supplied by local foundries.

It is pleasing to record that our activities as summarised here have earned the commendation of the parent Branch. The President of the London Branch, in a letter to our President, passed to us an expression of appreciation and congratulation from the London Branch Council. Thus, from the satisfactory results of our past efforts we are greatly encouraged to enter a new session resolved to maintain the interest and keenness which, expanded over the past six years, has caused the steady growth and development of the Section to its present position, a position in which every member is justified in taking pride.

On the proposition of Mr. G. Hall, seconded by Mr. D. Carrick, the report was adopted.

Election of Officers

The following were appointed:—

President: Mr. C. J. Lake.
Senior Vice-President: Mr. F. Tibbenham.
Junior Vice-President: Mr. C. H. Kain.
Secretary: Mr. J. L. Francis.
Councillor: Mr. R. Coates.

Mr. D. Carrick, in proposing a vote of thanks to Mr. Hall, the retiring President, said his term of office had been carried out most successfully under difficult conditions requiring very special efforts on Mr. Hall's part, especially as he resided so far away from Ipswich.

Mr. Francis drew attention to the fact that Mr. Hall had been instrumental in providing the core-drying oven installed in the foundry at the Ipswich School of Engineering in connection with the newly instituted foundry course.

Future Programme

The secretary announced that at the next meeting on April 18, Mr. A. F. Hammond would give full particulars, details and specifications, together with the necessary drawings of a "Specimen Casting" which presented some problems in patternmaking and founding. At subsequent meetings solutions to these problems would be offered and discussed generally.

Catalogues Received

Surface Hardening.—A very interesting leaflet has reached us from the Electric Furnace Company, Limited, of Netherby, Weybridge, Surrey. It describes and illustrates an apparatus for the surface hardening of engineering components by the use of electric induction. The machine is known as the Tocco, and the "Junior" model is available in five sizes, ranging from 10 to 80 kw. The system is the essence of simplicity to operate, the hardening being effected in a split second by induction heating through hysteresis and eddy currents associated with the pressure spraying of the heated surface with a suitable quenching medium. Those founders interested in surface hardening should certainly write for this pamphlet.

Automatic Electrolytic Processes. — The Electro-Chemical Engineering Company, Surrey, have sent us a well-illustrated brochure which describes in great detail a fully automatic plant for the carrying out of electrolytic work. The method of working is easily understood from a series of eight line drawings which set out the sequence of the movements. It is obviously a serious labour-saving proposition and one capable of extension to allied processes, such as certain types of enamelling and, maybe, pickling. It is of interest to record that one motor suffices for quite an intricate series of motions.

New Alloy. The Brookside Metal Company, Limited, of Astra Works, Harland Estate, Honeypot Lane, Stanmore, Middlesex, have issued a ten-page nicely-illustrated brochure which tells of the development of a 58 to 62 per cent. Zn, 35 to 38 per cent. Al and 2 to 4 per cent. Cu alloy, which as a sand casting will give 18 to 22 tons per sq. in. tensile associated with 1.5 to 2.5 per cent. elongation. The die-cast test-pieces show slightly improved figures. Much technical data are given in respect to salt spray tests, casting characteristics, machining properties and surface treatments. Already the material is entering into important components for use by the Armed Forces. The alloy has been placed on the market.

Random Shots

A keen metallurgist, hoping to impress a medical friend, was telling him a few of the troubles he has to contend with in his work amongst metals. "Do you realise," said he, "that metals suffer from disease and breakdown in just the same way that your patients do?"

"Tell me just one thing," interrupted the medico, after listening politely to a veritable discourse on fatigue, stresses, scabs and the like. "Does cast iron ever suffer from a lack of a good juicy beefsteak?"

* * *

Amongst the stamps issued by Brazil since the war is one catalogued by Gibbon's as "Ironfoundries." This might have been causing some uneasiness amongst foundrymen who are at the same time philatelists, fearful lest Brazil had been setting up its own iron industry during the reduction of imports. They may, however, set their minds entirely at rest, for ironfoundries is obviously a misnomer on the part of the catalogue compiler. The stamp depicts a view of a works with a brawny workman in the foreground and bears the inscription, "Siderurgia." A better translation of this would be smelting works and probably in this case refers to copper.

* * *

A perusal of the Paper recently read by Mr. E. R. Francis before the London Branch shows that whilst he has obviously "a nose for noos," his real interest in life is juggling with statistics. In thus finding enjoyment, pure and unadulterated, in the realm of figures he is not alone, apparently; but would one expect to find an English admiral expressing the view that arithmetic is "one of the most curious and entertaining sciences that can be conceived." So wrote Admiral Lord Collingwood to his daughters early in the nineteenth century, adding that "the characters which are used, the 1, 2, 3, are of Arabic origin; and that by the help of these, by adding them, by subtracting them or dividing them, we should come at last to results far beyond the comprehension of the human mind without them, is so wonderful that I am persuaded that if they were of no real use, they would be exercised for mere entertainment; and it would be a fashion for accomplished people, instead of cakes and cards at their routs, to take coffee and a difficult question in the rule of three, or extracting the square root."

"Marksman."

Book Review

Memorandum on the Inspection of Arc Welded Work—Welding Memorandum No. 7. Issued by the Advisory Service on Welding, Ministry of Supply, Department of the Controller-General of Research and Development, Great Westminster House, Horseferry Road, London, S.W.1.

This is the best practical publication the reviewer has ever seen on the subject of assessing the relative value of welds made by deposited metal. When a foundryman receives a machine which incorporates welded parts, he will, after reference to the illustrations in this book, be fairly sure as to whether he has received a workmanlike job. The reviewer, as a metallurgist possessing only a layman's knowledge of welding, has on theoretical grounds consistently urged the peening of welds with the object of increasing the tensile strength of the weld metal. Now he realises and appreciates that inspection is more reliable if carried out on unhammered welds. The pamphlet is most valuable and can with benefit be studied by everybody who is connected with engineering

Foundry Production Problems with Special Reference to High Duty-Alloy Cast Iron*

By A. E. McRAE SMITH

The subject chosen is rather a thread-bare one, since so much has been written about high-strength and special-duty cast irons in the last few years. There are two main fields covered by these cast irons, the first relating to really high-strength material and the other to cast irons of special composition for special purposes where their particular properties, such as resistance to corrosion, resistance to wear and resistance to heat make them particularly suitable. The latter class of cast irons may be of comparatively high alloy content, such as austenitic cast irons, high-silicon, high-chromium and even high-tungsten cast irons, whereas high-strength cast irons are usually of low alloy content. The properties of all these types of alloy cast iron depend largely on the kind of structure produced rather than the actual quantity of the alloying elements present.

Inspection

It is not intended to deal in great detail with the metallurgical and compositional aspects of high-strength cast irons, but rather to discuss elementary principles and tendencies in foundry technique, which will ensure the production of really sound castings. Inspecting bodies have not seriously applied the art of radiology for proving complete freedom from defects in grey-iron castings of any category. No doubt this, or similar developments, will ultimately have to be faced by iron foundries, and castings, which to all intents and purposes appear to be completely sound either in the as-cast condition or even after deep machining, might not be acceptable for really severe service if underlying defects were revealed by radiology or other method of internal inspection, as is done with certain types of steel castings and more frequently with aluminium and magnesium alloy castings.

At the same time, it is incumbent on the foundry industry to remember that, when producing high-strength iron castings, it is essential that the mechanical properties should be as nearly consistent as is possible throughout the whole mass of the casting, whether it is of light, medium or really heavy sectional thickness.

This question of complete soundness and freedom from liquid shrinkage defects in high-strength cast iron becomes more and more important as the duty demanded from such castings becomes more arduous.

When dealing with low-strength grey-iron castings exhibiting mechanical properties in the range of 11 to perhaps 16 tons per sq. in. tensile strength, minor unrevealed liquid shrinkage defects are not nearly so disastrous, provided the castings are pressure tight, as is the case when the material has to exhibit mechanical properties in excess of the highest British specification, namely, B.S.S. 786, Grade 4.

Before discussing ways and means of ensuring that all castings leaving a foundry after effective scrutiny by Inspection Departments are really 100 per cent. sound, a few brief remarks on the types of cast iron and the processes used for the manufacture of high-strength castings may not be out of place.

Inherent Difficulties

A good deal has been heard in recent years about the manufacture of alloy iron castings, and it is also very common knowledge that alloy additions normally react in two distinct ways. At one time some attention was given to the effect which such alloys have on the matrix of any particular type of cast iron, but latterly equal and perhaps more attention has been given to the production of cast iron with graphite structures which will have the least possible weakening effect on a high-strength matrix. In other words, it is useless to produce a cast iron with a matrix probably with a tensile strength of 40 to 50 tons per sq. in., but in which the amount of free carbon, as well as its size and arrangement, is such as to produce a material which, in its final form, has very poor mechanical properties indeed. Theoretically the alloying of cast iron should produce a matrix with equal mechanical properties to those of a steel of similar composition, neglecting the carbon content. This, of course, does not take place in actual practice, because cast irons always contain free graphite. If this free graphite is also in the form of very large flakes, then the difference between the potential and actual strength of the matrix will be much greater than would be the case with a similar amount of graphite in small flakes. However, this is not the whole answer, because it is found that most high-strength grey cast irons with a total carbon content under 2.7 per cent. very often do not give the anticipated mechanical properties. It is obvious that in grey cast iron, provided all other conditions such as base composition, alloy content, mass, sectional thickness, rate of cooling, casting temperature, etc., are equal, the actual tensile strength will depend on the total carbon content. The higher the total carbon content and, therefore, the greater the amount of free graphite present, the lower will be the strength. In point of fact, this does not always work out according to plan in actual practice, because it has been found by long experience that in the lower range of carbon content, say under 2.7 per cent., cast irons are prone to exhibit a graphite arrangement which has been variously described as eutectic graphite or more recently "grain boundary" graphite. When this type of graphite arrangement is present in a casting, it is a well-known fact that the mechanical properties are always very much inferior to those containing the same amount of free graphite, where it is arranged in random patterns.

Discussion of this subject in any detail is far beyond the scope of this Paper, but avoidance of eutectic patterns or grain boundary graphite is the very first essential for the production of really high-strength cast iron. The importance of this was very well illustrated by a number of papers on the subject of graphitisation and the general behaviour of graphite in cast iron given before the American Foundrymen's Association at the Annual Convention during May, 1941. It would repay any foundryman specially interested in the production of high-strength cast iron to peruse very carefully these Papers. Perhaps the most important, and from the foundryman's and metallurgist's point of view the most illuminating, is that entitled "The Development and Control of Engineering Grey Cast Irons," by R. A. Flinn and D. J. Reese.† This Paper deals very fully and very effectively with the properties and control of graphite structures in grey cast iron. In brief, the authors show that the structure of grey cast iron must be considered from two aspects, namely, (1) the graphite flakes, and (2) the matrix. They show that the amount of graphite will have a decided effect on strength properties and that one of the most important points about graphite is its distribution or arrangement. They emphasise the poor properties associated with so-called eutectic graphite, and conclude that the most favourable properties are always shown by irons with evenly distributed, fairly fine graphite in random formation. They also give very lucid and conclusive proof how these two forms of graphite tend to be produced.

The *appearance* of typical "grain boundary" and random type graphite formations is, of course, familiar to most, but the following typical examples may serve to refresh one's memory. Fig. 1 shows so-called eutectic or grain boundary graphite producing a very weak structure. The graphite flakes in themselves possess very poor mechanical properties, and it cannot be too strongly emphasised that it is useless to endeavour to produce a high strength cast iron by strengthening the matrix if the graphite distribution is unsuitable.

Economic Production

This leads naturally to discussing briefly the best and most economical methods of producing cast irons with high strength matrix structures. It is not intended to discuss cast irons with intermediate mechanical properties such as comply with the minima laid down for grades 1 and 2 of B.S.S. 786, but rather to consider, in a very general way, suitable compositions for cast irons to meet Grades 3 and 4, and more particularly those with mechanical properties considerably in excess of Grade 4.

The usual method of producing cast iron to meet the requirements of Grade 3 is to adopt one of the special process cast irons, usually with a total carbon content in the range of 2.7 to 2.9 per cent. with suitable alloy content. This alloy content usually consists of one or more of the following elements, namely, copper, nickel, chromium and molybdenum, either individually or in combination. All foundrymen are to-day acquainted with these cast irons, the most common types of which are those manufactured by the inoculation processes, such as Ni-Tensyl iron and the higher grades of Meehanite. Their production in the foundry calls for accurate metallurgical control, so that a correct carbon/silicon ratio may be maintained for any particular range of alloy content in order to ensure that the amount of combined carbon will be somewhere between 0.7 and 0.9 per cent., so as to promote fully pearlitic structures. Another variable, of course, is always present, namely, the cooling rate of the casting which will vary very widely with the mass and sectional thickness of different castings. Everyone is familiar with the mechanism of arranging percentages of total carbon, silicon and the alloy composition to suit different sectional thicknesses. If the carbon/silicon ratio is reasonably correct, the castability of these irons is good, but when the total carbon content approximates the lower figure, namely, 2.7 per cent., or may in fact be less than that, then their liquid shrinkage characteristics are not so good. It will be shown later how foundry technique must be adjusted to overcome this. Of the common alloying elements, it is well known that molybdenum is the most effective in increasing the tensile strength of grey pearlitic cast iron. This element is much more expensive than either nickel, copper or chromium, and consequently the special process irons, such as Ni-Tensyl iron and Grade A Meehanite, can be more cheaply produced than alloy cast irons containing molybdenum.

Molybdenum Additions

This leads us to consider a second method for the production of alloy grey cast iron to meet the Grade 3 specification, which is the use of base compositions with medium total carbon contents in the region of 2.9 to 3.2 per cent.

* A paper read before the Scottish Branch of the Institute of British Foundrymen.

† See "Foundry Trade Journal" of January 8, 15 and 22.

FOUNDRY PRODUCTION PROBLEMS

FIG. 1.—SHOWING EUTECTIC OR GRAIN-BOUNDARY GRAPHITE.

FIG. 2.—ACICULAR-STRUCTURED NI-MO CAST IRON FROM CRANKSHAFT CASTING.

FIG. 3.—(SAME AS FIG. 2).

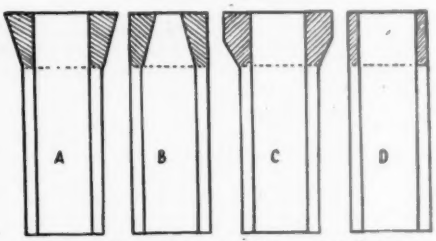

FIG. 4.—TYPICAL FEEDING HEADS FOR SLEEVE CASTINGS. A, B AND C—SATISFACTORY. D—UNSATISFACTORY.

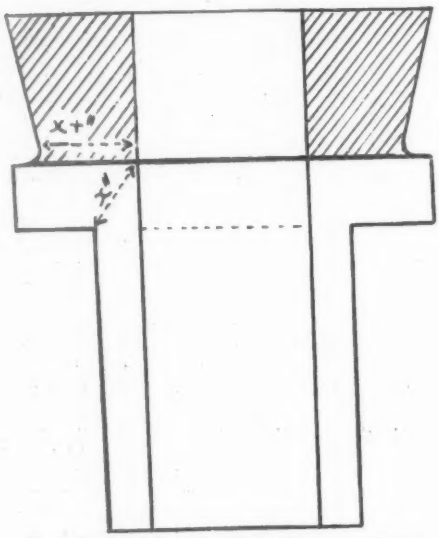

FIG. 5.—TYPICAL FLANGED BUSH OR LINER WITH FEEDING HEAD (SECTION THROUGH CENTRE). NOTE: DIMENSION x + " MUST BE GREATER THAN x" TO ENSURE PROGRESSIVE SOLIDIFICATION.

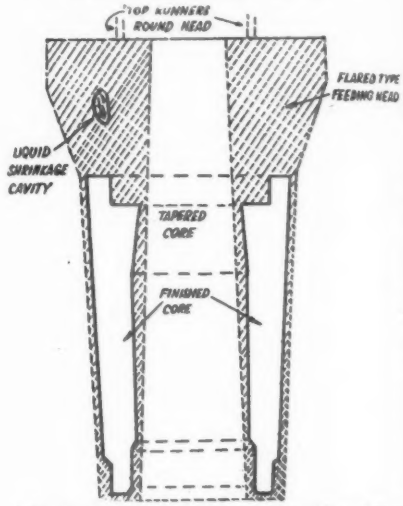

FIG. 7.—PIERCING POT DIE FOR HOT STEEL FORGINGS (LONGITUDINAL SECTION). DIE POT IS CAST VERTICALLY WITH HEAVY SECTION ON TOP TO PROMOTE PROGRESSIVE SOLIDIFICATION.

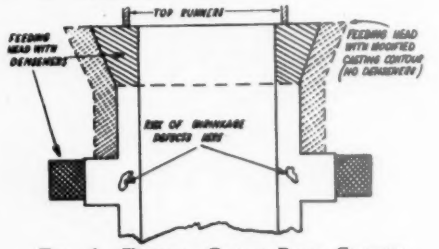
TOP RUNNER
FEEDING HEAD WITH DEMEMBERS
FEEDING HEAD WITH MODIFIED CASTING CONTOUR (NO DEMEMBERS)
LINE OF SHRINKAGE DEFECT

FIG. 6.—TYPICAL GLAND RING CASTING (SECTION THROUGH CENTRE).

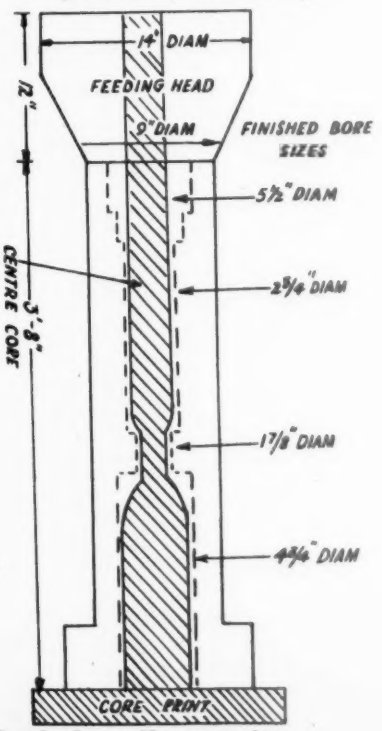

FIG. 9.—LATHE HEADSTOCK SPINDLE.

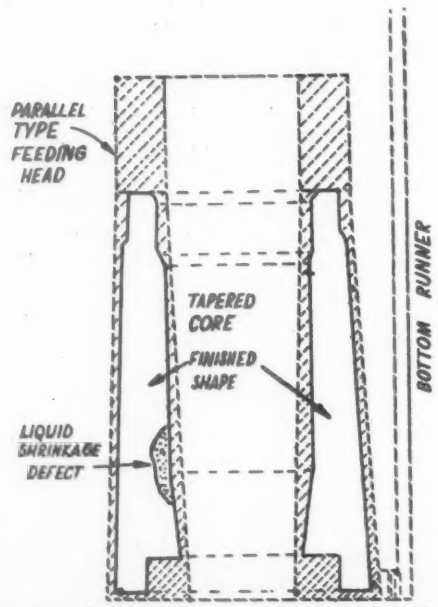

FIG. 8.—PIERCING POT DIE FOR HOT STEEL FORGINGS (LONGITUDINAL SECTION). UNSATISFACTORY METHOD.

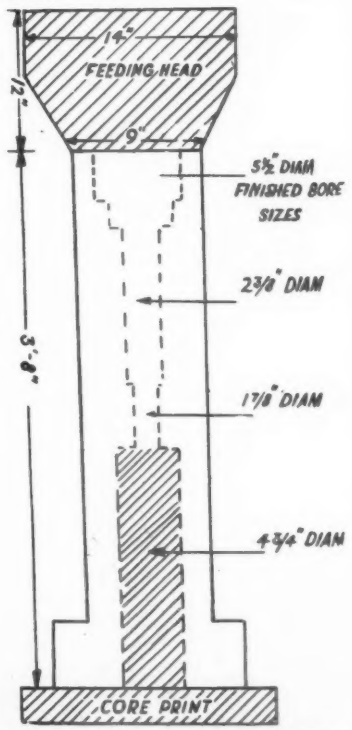

FIG. 10.—LATHE HEADSTOCK SPINDLE.

Foundry Production Problems

with or without the aid of late silicon additions. As far as cupola practice is concerned, particularly for foundries which are lacking in technical and metallurgical control, it is easier to use a cast iron of this type with nickel and/or copper additions coupled with small molybdenum additions of the order of 0.3 to 0.5 per cent. molybdenum. These cast irons are easier to handle in the foundry and, on account of the higher total carbon content permissible, have better liquid shrinkage characteristics compared with the lower total carbon compositions. Where cupola melting is the only process available, they can be made with only small, or even without, additions of mild steel scrap, provided the greater portion of the base charge consists of so-called refined iron or low-phosphorus medium-carbon types of pig-iron. The lower carbon irons, of course, require the use of comparatively high percentages of steel scrap when they are made by cupola melting. It is not the intention in this brief survey to deal with low-carbon irons produced in rotary furnaces, electric furnaces, etc., where, of course, it is easy to obtain low-carbon compositions even when using quantities of medium-carbon and high-carbon material in the case charge.

The foundry technique required for producing comparatively complicated castings of divergent sectional thickness in these alloy cast irons of medium carbon content, differs very little from that associated in the past with so-called cylinder irons. Since, in order to maintain high strength, the phosphorus content will be comparatively low, seldom reaching a figure above 0.4 per cent., casting difficulties usually associated with high phosphorus contents, particularly in heavy section castings, do not arise.

Of much more interest to progressive foundrymen at the present time is the production of really high-strength grey cast iron possessing mechanical properties in excess of the minima called for in B.S.S. 786, Grade 4. As is well known, this specification calls for a minimum tensile strength of 25 tons per sq. in. on test-bars cast 0.875 in. dia. In order to meet this specification satisfactorily, a certain plus margin is necessary, which means that average tensile strengths in the routine production of castings to meet this specification must be about 27 tons per sq. in. In point of fact, a considerable amount of cupola melted cast iron is being made to-day with a minimum tensile strength of approximately 30 tons per sq. in. in the as-cast condition, and figures of 35 tons and over are not uncommon.

Acicular Structures

It is difficult to obtain cast irons with a tensile strength much over 25 to 28 tons per sq. in., in the as-cast condition, when pearlitic structures only are employed. A great deal of attention has been given lately, particularly in the technical Press, to nickel-molybdenum cast irons usually with a molybdenum content of over 0.5 per cent., where the production of a so-called acicular structure is utilised to produce high mechanical properties, including high tensile strength, transverse strength and toughness. In this connection, reference might again be usefully made to the recent Paper by Flinn and Reese, where it is demonstrated that the new high-strength acicular structures may be produced and controlled to give strengths much in excess of those associated with pearlitic cast irons. In this Paper tensile strengths up to approximately 47 tons per sq. in. are quoted.

A very important series of nickel-molybdenum cast irons has recently been developed, usually containing molybdenum in amounts varying between 0.5 and 1.5 per cent., and with nickel contents varying between 1 and 5 per cent., the nickel content being varied according to the cooling rate of the casting, the smaller the sectional thickness or mass of the casting, the lower the nickel content, all other things being equal. These cast irons, which, as already indicated, are characterised by high tensile strength and great toughness, owe their properties entirely to the structure of their matrix, always provided, of course, that flake graphite in random form is present to the exclusion of eutectic graphite. Within the range of composition given above, when correctly adjusted to the cooling rate of the casting, austenite does not transform to pearlite. Instead, at temperatures very much lower than the normal change point intermediate decomposition products are formed, and these consist largely of free ferrite needles, together with residual austenite high in carbon.

Studies of a number of such nickel-molybdenum cast irons have clearly established the fact that this type of acicular structure consists of a series of austenitic decomposition products which form below the pearlitic temperature range by the precipitation of free ferrite and diffusion of carbon into the surrounding austenite. Provided the composition is suitable, a subsequent low-temperature annealing treatment, usually in the neighbourhood of 320 deg. C., will completely change the residual austenite into a wholly acicular structure. This tends to increase the tensile strength, with but a slight reduction in toughness or resistance to impact as measured by single-blow impact tests. In other words, in these acicular structured nickel-molybdenum cast irons maximum toughness is obtained in the as-cast condition if a proportion of free austenite remains, whereas maximum tensile strength with only a moderate reduction in toughness is obtained after low-temperature heat-treatment, when the residual austenite is completely converted into the needle-like structure.

Figs. 2 and 3 show typical structures of cast iron of this type. The micrographs are taken from some actual crankshaft castings for small compressors, with a sectional thickness of 1⅛ in. dia. at the point where the test-pieces have been obtained. The tensile strength of this particular sample was 34.6 tons per sq. in., and after low-temperature treatment the tensile strength was 38.2 tons per sq. in. The composition was as follows:—Total carbon, 2.89; silicon, 2.28; manganese, 0.97; sulphur, 0.13; phosphorus, 0.097; nickel, 2.30; and molybdenum, 1.25 per cent.

Future Field for Iron Castings

The above details are given merely as a very rough guide, and as typical examples of what may be achieved from cupola melted iron. It will be noted that the phosphorus content is very low. This is important, because phosphorus in excess of 0.20 per cent. tends to favour the formation of pearlite with a sudden decrease in mechanical properties for any given alloy and carbon content. The same type of composition, of course, may be applied to the special process irons which are covered by British Patents. It is felt that these alloy cast irons of medium carbon content will eventually prove very acceptable to engineers, who require high strength, tough materials which have the peculiar properties and characteristics associated with graphitic cast iron.

In fact, if one may dare to put forward a mild prophecy, one can visualise a time when the intermediate strength grey cast irons might cease to be used except for limited and special fields of application. The industry would then be left with the straight phosphoric cast irons of low strength, which will, of course, always cover a vast proportion of grey-iron requirements and the really high-strength cast irons comparable in tensile strength with steel castings and forgings, but also possessing the special characteristics of true cast iron. For example, they will still possess the inherent lubricating and wear-resisting properties of all types of graphitic cast iron, will have high capacity for absorbing vibrations, etc., and will also possess a high order of resistance to notch sensitivity.

Under a state of affairs thus visualised, the medium-strength alloy and non-alloy cast irons would still find a useful field on account of their special properties, such as high wear resistance, etc. For example, the grey martensitic and white martensitic cast irons will continue to be used more and more extensively. Low alloy additions coupled with moderate strength base compositions will also find employment for promoting pressure tightness and for heat resistance under suitable conditions, etc. Dictates of initial cost will also influence any such change-over and tend towards the retention of medium-strength cast iron.

When considering all this, it must be remembered that the highest strength nickel-molybdenum irons are true cast irons, and therefore are non-ductile materials, although possessing very much superior shock-resisting qualities compared with ordinary phosphoric cast irons. Another point in favour of the nickel-molybdenum cast irons of acicular structure is that moderately high strength can be obtained with very good castability, since the total carbon content need not fall much under 3.0 per cent.

Pressure-Tight Castings

It was mentioned earlier that in the production of high-strength cast iron great attention must be paid to obtaining completely sound castings free from all traces of liquid shrinkage porosity. This is of the greatest importance when dealing with cast irons of this class on account of the types of service to which such castings are usually put. It is true that in the production of pressure-tight castings from weaker grades of non-alloy cast iron, freedom from liquid shrinkage defects is also important, but the common bedplate, the common flywheel, etc., made in various grades of iron, having tensile strengths falling between perhaps 11 and 18 tons per sq. in., can often carry under their skin considerable areas of weak structure without impairing their efficient use in service. This is not the case in regard to castings which have to be pressure tight, nor is it the case with castings which must have uniform strength throughout their mass.

No doubt many founders, particularly in Scotland, are finding considerable difficulty to-day in obtaining sound castings in medium-strength cast iron when producing designs which they have made successfully for many years. This can in very great measure be accounted for by higher phosphorus contents of the raw materials which they are using, another element which also tends to increase susceptibility to internal liquid shrinkage defects in heavier section castings. Therefore, it may not be amiss to deal briefly with foundry technique, with particular reference to the progressive solidification of castings and the provision of adequate feeding metal where the design of casting is such as to make liquid feeding difficult or where the characteristics of the metal, either on account of high phosphorus content or low total carbon content, are such that the difference in volume from the liquid to the solid state is greater than normal.

It is, of course, well known that cast iron, compared with other metals, has comparatively low liquid shrinkage characteristics. The actual amount of liquid shrinkage will depend very largely on the carbon content, or rather depend on the amount and size of the graphite particles. The amount of actual liquid shrinkage, that is, as already stated, the difference in volume between the solid and the liquid from which it is formed, will probably vary between approximately 1 per cent. for high-carbon hematite type cast irons, up to 3 per cent. for medium low carbon cast irons, and considerably more for cast irons with a total carbon content of 2.5 per cent. and under. If, however, a grey-iron casting, whether in high-strength or low-strength material, was of such a design that solidification could take place progressively from the bottom of the casting upwards, or, in exceptional cases, could take place simultaneously throughout its whole mass, then it would be a

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very simple matter to counteract this difference in volume between the solid and the liquid state. Unfortunately, this is not the case.

The question of internal inspection of castings by radiology was briefly mentioned at the beginning of this talk, and in all seriousness it is suggested that founders specialising in the production of high-strength iron castings should prepare themselves for this type of inspection being applied to their castings in the future.

Another interesting sidelight on the degree of perfection of castings has come to light recently when applying the process known as "Induction Hardening" to cylinder liner bores. A recent article* by Fredk. P. Peters and Edwin F. Cone, dealing with this process, contains the following statement:—"An interesting side feature of the process for the induction hardening of cast-iron liners is its simultaneous use as an additional inspection where the part being treated is porous or cracked. An abnormality of the heating occurs within the piece and manifests itself by melting the surface or wall adjoining the defect. In the case of porosity, marked signs of overheating can be discerned. Consequently defective stock can be easily identified. In fact, defects otherwise discernible only by Magnafluxing or microscopic inspection are readily revealed in this way."

Cylinder Liners

The point made above is of particular interest to the speaker, because probably there has been more controversy ranged around methods of casting cylinder liner castings of all types in the foundry industry than with any other variety of component. For example, very often a foundry strikes trouble with small-bore, thin-walled liners, which are sand cast, after obtaining reasonably satisfactory commercial results over a long period previously, and cannot understand why this has occurred. A personal answer to that is, unless the castings are of an extremely thin-walled nature, some microscopic liquid shrinkage defect will almost invariably be present, but it may not be revealed by machining, or, if it is, the defect is so minute that it is overlooked by normal methods of inspection. Slight variations in composition and cooling rate, etc., will tend to increase or decrease the magnitude of this defect, and consequently it will be sufficiently great in some batches of castings to be readily visible and cause rejections. Directly opposed to this there are the manufacturers of Diesel liners for main propulsion marine engines, who cast liners with very little difficulty up to probably 5 tons in weight and 30 to 40 in. in diameter, but probably it will be found that almost invariably their practice is to use suitably designed feeding heads to provide liquid metal to feed the remainder of the castings during the process of solidification. To continue on these lines a little further, occasionally one encounters a particular type of Diesel engine liner, the design of which is such that it may carry a flange at some intermediate point between the top and the bottom of the casting. It is well known in Diesel engine foundries that this is a very difficult type of liner to produce, and that some artificial method, such as the use of denseners, has to be adopted to prevent defects due to liquid shrinkage porosity at that point.

It may, of course, be argued, and it is postulated by some authorities that these liquid shrinkage troubles are only characteristic of high strength and special cast irons. This unfortunately is very far from the truth, because a great many of the castings such as automobile cylinder blocks and cylinder heads, Diesel cylinder liners and forging dies, to mention only a few examples, in the form and design often

(*Continued in next column.*)

* "Metals and Alloys," June, 1941.

(*Continued from previous column.*)

called for could not possibly be produced free from liquid shrinkage defects in high phosphorus irons without resort to similar and even more drastic precautions. It is well known that high carbon irons, usually associated with relatively high silicon contents, possess greater castability than high strength irons, but if they were used for the production of many types of lumpy heavy section castings, the resulting material would be so open-grained as to be useless.

Therefore it will be seen that in order to get close-grained, strong material it is necessary to have resort to cast irons whose castability and liquid shrinkage characteristics are not quite so good. On the other hand, of course, as far as high strength cast irons are concerned, they are usually of low phosphorus content, and this to some extent offsets the difference.

(*To be continued.*)

East Midlands Branch Annual Dinner

The annual dinner of the East Midlands Branch was held in Derby on March 19, 1942. The Branch-President (Mr. H. J. Beck) presided and was supported by Mr. C. W. Bigg, Past-President of the Institute, Mr. W. T. Evans, Mr. T. Goodwin, Mr. A. E. Peace, Mr. H. Bunting, Mr. R. H. Buckland, Past Branch-Presidents, and fifty members. The following guests honoured the Branch by their attendance: His Worship the Mayor of Derby (Alderman H. G. Pattison), Dr. H. O'Neill, M.Met., D.Sc. (Head of the Research Laboratory, the London Midland & Scottish Railway Company), Major R. Miles, M.Eng. (President of the Institute of British Foundrymen), Major F. D. Ley, J.P. (managing director of Messrs. Ley's Malleable Castings Company, Limited), and Mr. J. Bolton (assistant secretary of the Institute). Apologies were received from Dr. Richardson (Derby Technical College), Mr. T. Makemson and Mr. S. H. Russell.

A Metallurgist's Appreciation

When proposing the toast of "The Institute of British Foundrymen," Dr. H. O'Neill said that, although he was not a member of the Institute of British Foundrymen, he made use of the Institute's work, and he had been impressed by the quality and volume of this work. He admired the Proceedings—especially in its new form—it was a creditable publication, being splendidly arranged and containing many excellent Papers. The Institute had carried on magnificently during the war, although circumstances had been adverse; the continued large attendances at the Branch and Council meetings were an indication of general enthusiasm.

Dr. O'Neill then outlined several of the scientific advances made in foundry work during the last 20 years and added that although some insist that welding would replace the cast article, if it be so desired consolation would be found in the fact that welding was only casting. Again praising the Institute, Dr. O'Neill said he thought it set a well-balanced example of successful co-operation between those who worked in the laboratory and those who worked in the shops. Continuing, he said he admired its international outlook. Internationalism could be overdone, but he thought the Institute was correct in having consistently supported international metallurgical congresses. It recognised that mankind the world over was interested in the same kind of things; people had to live together and he, for one, was looking forward to the time when these congresses could be resumed. There was at the present time much talk about scientists taking a greater share in the affairs of the country after the war, but he personally did not believe scientists knew enough about human nature to make a success of such an immense task.

Major R. Miles responded in a lively and humorous manner. He reiterated several points he had emphasised in his presidential address, stating that the only excuse he could offer the members present was that at least he was being consistent.

Giving a toast to the East Midlands Branch, Mr. J. Bolton remarked that the locality was certainly not behind any other area in the country so far as a high standard of foundry practice was concerned. The East Midlands Branch, including, of course, the Lincolnshire Section, had carried on its duties extraordinarily well; regular meetings had been held throughout the session and there had been a general keenness for the work of the Institute. He specially commended the Branch-President and secretary for the great help they had given.

A Local Record

Mr. H. J. Beck, responding on behalf of the Branch, urged the younger members of the Institute to continue their training during the present emergency, and to absorb as much technical knowledge as possible despite the difficulties. There would be a testing time when this war was over and the responsibility for bringing the foundry industry safely through would be mainly their task. If a young man was considering applying for a responsible job in the industry, he must be sure that he could fill it successfully before accepting it; if not, trouble would ensue. Foundry management could not afford to pay high salaries for no return. Concluding, Mr. Beck remarked that when he retired from the Presidency in June, four Past-Presidents, including himself, would have between them served the Institute for 80 years and a local firm for 100 years. He would suggest that this was a record difficult to surpass by any other Branch of the Institute.

Mr. G. L. Harbach, proposing the toast of "The Guests," said the visitors had shown wide knowledge of the work of the Institute and of the Branch—all speakers had shown they had an excellent sense of humour. Major Miles excelled in this respect and he thought all present would agree that this gathering was one of the happiest possible.

His Worship the Mayor of Derby (Alderman H. G. Pattison), speaking on behalf of a distinguished body of guests, who had shown a considerable interest in the work of the Institute, praised the technical and practical skill of the foundryman and emphasised that if it were not for their work, the country would not be able to carry on the war. The Mayor expressed the view that there was too much talk about post-war planning—once the war was over, the peace conditions could be settled.

Major F. D. Ley supported the Mayor, expressing pleasure for a most enjoyable evening on behalf of all the guests.

A musical entertainment followed.

Castable Refractories

A new light-weight insulating castable refractory, recommended for service with temperatures as high at 2,200 deg. F., and made by the Plibrico Jointless Firebrick Company, Chicago, is applicable where refractoriness is required with high-insulating efficiency. It is especially suitable for lining furnaces used for heat-treating, annealing, stress-relieving, and carburising, and for lining ducts, breechings, etc. Another valuable application is for backing certain types of water walls in steam boilers, when tube spacing and operating temperature permit. Called Plicast L-W-1, the material weighs 57 lbs. per cub. ft., and sets in 12-24 hrs. with a compressive strength of 1,485 lbs. per sq. in. Thermal conductivity, in B.Th.U. per sq. ft. per in. of thickness per hr. per deg. F., is 1.80, 2.15, and 2.35 at mean temperatures of 400, 800, and 1,200 deg. F. respectively. Heat storage capacity is said to be 60 per cent. lower than that of fire brick.—"Iron and Steel Engineer."

The Foundry Industry and Air Warfare

I—THE GENERAL BACKGROUND

For many years Germany has been extremely successful in her propaganda designed to convince the nations of the world of her scientific and technical pre-eminence. No nation has a monopoly of brains, but the notion that "Jerry" has some sort of a controlling interest in them requires refutation from as many angles as possible, and the one we have chosen is the publication of a series of articles based on the superiority of the Royal Air Force over the Luftwaffe. Of all industries, surely that of aircraft production is essentially based upon the sciences of metallurgy, mechanics and aerodynamics. The superiority of the R.A.F. would, and could, not have been achieved if our machine tools were inferior to those at the disposal of Hitler; if our instrument makers were but second-rate mechanics, and our metallurgists unworthy to wear the cloaks of Bessemer, Siemens, Thomas and Gilchrist, the last of whom, incidentally, made this war possible for the Germans to wage. The blunt truth is that, with the ascendency of the Hitler régime, there has been a progressive decline in the standard of German research and technical efficiency. Unfortunately, the result of German propaganda, reinforced perhaps by British modesty, has been a general belief that German foundry practice is ahead of the rest of the world. Quite recently an Englishman, writing to the President of the South African Branch of the Institute of British Foundrymen, lamented that the finish of British castings was inferior to those shown on components made outside the Empire. If the writer of this letter had had the experience of examining those dark grey skinned castings to be associated with the heavy German iron-foundry industry, he would wonder how they could be machined at an economical price! Or, again, what would he say if he heard in a café in the Ardennes a stranger within earshot asserting: "Les meilleures moulages du monde, ne sont pas fabriquées dans les Ardennes, mais par un maison anglaise!" (The world's best castings are not made in the Ardennes, but by an English concern.)

Thus, when one reads that since the opening of the Libyan campaign, the R.A.F. and their colleagues from the Dominions have, using mainly British aircraft, shot down over two hundred German and Italian machines, the admiration of the foundryman is properly accompanied by the thought as to just what part he has played in these victories. The iron-founder perhaps plays a minor role, but nevertheless an important one. There are certain components of the mechanical pilot—nicknamed "George"—which are made in the jobbing foundries of the type skilled in the production of high-duty castings. Again, these foundries are responsible for the production of many types of templates used in connection with wing fabrication, whilst a not inconsiderable business is the mass production of the bases of incendiary bombs. Apart from these direct castings, there are the innumerable castings required for the machine tools provided for the maintenance of aircraft parts, for use by the ground staff, and light castings for incorporation in aerodrome buildings.

The largest contribution which the steel foundry makes to the success of the R.A.F. is the provision of the steel castings for high explosive bombs, and everybody concerned with their manufacture is keyed up to give of their best, for they can easily picture the disappointment of a pilot and his crew when having risked their lives to ensure a certain hit on the target, faulty material or workmanship should nullify their efforts. Among the most exacting castings made by the steel foundry is a cylinder liner. Nothing less than perfection is permissible, so recourse is had to the centrifugal process of manufacture. To maintain the same expansion properties as the light-alloy cylinder an austenitic steel is used. The casting carries a shoulder which obviously adds to the difficulty of manufacture, as centrifugally-cast components still have to conform to the laws of directional solidification like ordinary sand-cast material. Cleanliness and soundness being essential, it has been widely established that the melting medium should be the high-frequency electric furnace, for thereby is given the assurance that, metallurgical control of the raw materials being assumed, there will result an inclusion-free metal cast at the correct predetermined temperature. Moreover, each casting will weigh, as cast, a hundredweight, but as delivered to the R.A.F. only about 12 lbs. This may superficially seem an extravagant method of production, but it is the set policy of the Ministry of Aircraft Production to incorporate the very finest material associated with the highest British craftsmanship in aeroplane construction, so that the crews may have a well-founded confidence in their machines.

An important contribution is made by the founder of heavy non-ferrous metals by furnishing phosphor-bronze sticks, from which bearings are machined, but the major onus is placed upon the light-alloy industry. Dozens of aluminium and magnesium foundries are daily turning out thousands of precision castings for incorporation in engines, framework and instrument panels, whilst the manufacture of incendiary bombs is an item of some magnitude.

The Customer

Though the ultimate consumer of aeronautical castings is the R.A.F., there is interposed between it and the foundry industry many dozens of factories, the job of which it is to machine and assemble them into aero-engines, aeroplanes and their component parts. The largest customer is the aero-engine builder, and as few foundrymen have had the opportunity of inspecting these establishments, what follows is descriptive of a typical works. It is germane to state that in pre-war days it was arranged that all the well-known makers of aero-engines should create and manage for the Government a minimum of two shadow factories. Naturally enough these new shops are brilliant examples of the very latest conceptions of shop design and equipment. Being permanently blacked out it is impossible to tell whether it is day or night, whilst the atmosphere is exceptionally pleasant, as throughout the works a controlled heat and air conditioning plant functions perfectly. The general spacious appearance of the shops is somewhat marred by the enclosure of the special-duty machines by blast-resisting walls and the construction along the side walls of personnel air-raid shelters. Great attention has been paid to the duplication of the services. Thus for a battery of a dozen or so heat-treatment furnaces, half may be fired with town's gas and half with producer gas, or oil. As a strict technical control is established, valuable data are being accumulated from these and similar cases for post-war publication, which should provide a sound basis for the economic selection of plant. In aero-engine construction, the use of castings is restricted to aluminium, magnesium and phosphor bronze (for bearings) castings, and in some cases centrifugally cast-steel cylinder linings. It was natural to ask if satisfaction was being given by the foundry industry, and it is pleasing to learn that, viewed from no matter what angle, there were minimum grounds for complaint. The only casting, which tended to show defects, was a volute casing cast in a magnesium alloy. Here the trouble was a tendency to exhibit micro-porosity in the bosses. It is not so pronounced, however, as to warrant return to foundry, but is sufficient to call for a letter of complaint. Put shortly, it is a defect of which the foundry needs constantly to be reminded to ensure that the quality which the R.A.F. demands and so richly merits is maintained. It can be stated without qualification that the aero-engine builders on their side spare no effort to ensure that the machines they turn out are of the highest possible quality. As is well known, easements have been made in a few specifications since the outbreak of war, whereby alloys, not necessarily compounded from virgin metals, are accepted in aircraft manufacture. These caused just a few headaches in the foundries initially, until the operatives acquired the knack of handling the substitute alloys; in aero-engine factories, however, the castings received have given entire satisfaction.

Blast-Furnace Coke

Hjalmar W. Johnson, in the course of a Paper on "Correlations of Some Coke Properties with Blast-Furnace Operation" to the American Institute of Mining and Metallurgical Engineers, presents data collected over the last eight years showing how variations in coke influence the operation of blast furnaces. All possible tests have been carried out on the cokes but main observations have been made on the performance of the coke in the actual furnace. The aspects considered in the Paper include:—(1) A discussion of a period when a change in the coke resulted in an increase in efficiency on one furnace and a decrease in efficiency on another; (2) adaptation of the inefficient furnace to the available coke so that normal efficiency was restored; (3) the use of radial distribution: a discussion of the effect of size of ore layer in adapting blast-furnace operation to the coke; (4) an example of a change in size of coke and the detrimental influence on the production of one furnace; (5) an example of a change in size of coke, together with manufacturing data, to show why it changed, the conclusion being that coke is a product with an optimum value; (6) illustration of the fact that coke has different optimum values on two furnaces, with discussion on adaptation of operation so the optimum values will be the same; (7) limitations of the use of screen tests as an objective measure of coke quality; and (8) importance of uniformity in coke.

Summarising the Paper, the author concludes that: (1) Before considering the quality of coke used, it is first necessary to adapt the furnace to the coke available. No conclusion regarding the quality of coke is worth while until the best possible gas flow has been worked out for the particular furnace. (2) Coke is a product that has an optimum value. Certain objective measures also have a maximum value. Consequently, it is impossible to establish any straight-line relationship between such properties and the results in a blast furnace. It was shown that the points of optimum value on two blast furnaces, as measured by flue temperatures and coke size, did not coincide. (3) The use of screen tests of coke as an objective measure of coke quality was discussed. It was concluded that the size of coke may be an indication of coke quality but is not a measure of it.

Development of Welding Technique

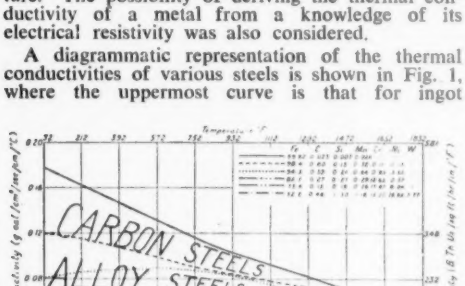
A special committee for the study of welding questions, which was formed in Sweden ten years ago as part of the Royal Swedish Institute for Engineering Research, has recently published the results of its work. The publication contains many articles on the welding technique and problems in various fields, *e.g.*, the advantages of welding in shipbuilding, how the weight of railway cars and locomotives can be reduced through welding, and the examination of welded joints by X-rays.

Thermal Conductivity of Steel

The thermal conductivity of some industrial materials was discussed in the course of a Paper presented recently to the Institute of Fuel by Dr. Ezer Griffiths, Dr. R. W. Powell, and Mr. M. J. Hickman.

A description was given of the various types of apparatus devised for high temperature thermal conductivity determinations. Data were given for refractories, insulating bricks, granular and fibrous materials, mica, carbon, graphites, and metals. The effect of impurities on the conductivity of iron was shown to be less at high than at normal temperatures. In addition, the values at a particular temperature lay reasonably well on a smooth curve when the thermal conductivity was plotted against the total equivalent carbon content of the added elements. The thermal conductivity of carbon was much less than that of metals, whilst one of the natural graphites studied had a conductivity exceeding that of copper at normal temperatures. Its conductivity, however, decreased very rapidly with increase of temperature. The possibility of deriving the thermal conductivity of a metal from a knowledge of its electrical resistivity was also considered.

A diagrammatic representation of the thermal conductivities of various steels is shown in Fig. 1, where the uppermost curve is that for ingot



Variation of thermal conductivity of iron and steels with temperature

Fig 1.

iron. The determination from 0 deg. to 800 deg. was made in the first instance by the absolute longitudinal heat flow method. This portion of the curve has since been confirmed by measurements obtained with the radial heat flow method, and using this latter method the results were extended to 1,000 deg. C. In the course of this later work, the transformation region of iron was studied closely, using a temperature difference of only 6 deg. C. to 8 deg. C. a series of values was obtained over the temperature range 700 deg. C. to 920 deg. C. at intervals of about 20 deg. C. No change or discontinuity was detected at the magnetic transformation point (*i.e.*, 770 deg. C.), but in the neighbourhood of the α to γ transformation point (*i.e.*, 910 deg. C.) the thermal conductivity has a minimum value. Thus, whereas the thermal conductivity of α iron has a negative temperature coefficient, γ-iron has a small positive coefficient.

The second curve in the figure is for one of the series of 21 steels already mentioned, a 0.γ per cent. carbon steel, and here again the region from 700 deg. C. upwards has been studied in detail using the radial heat-flow method. At about 730 deg. C., which is the temperature where this steel transforms from the α to γ-phase, the thermal conductivity is now seen to decrease suddenly from 0.070 to 0.057 g.-cal./cm.^{2}/sec./deg. C./cm. Once again, the conductivity of γ-iron has a positive temperature coefficient.

Fig. 1 also contains results to 700 deg. or 800 deg. C. for an alloy steel containing principally about 3.5 per cent. nickel, and for three more highly alloyed steels. Two of these, an 18/8 stainless steel and another containing 26.86 per cent. Ni, 15.2 per cent. Cr, and 27.7 per cent. W, are austenitic steels where the γ-phase is present from room temperatures upwards, and the conductivities of these are both seen to have positive temperature coefficients which appear to be a characteristic of γ-iron. Other carbon, alloy and high alloy steels have been studied to moderate temperatures, and the results lie within the zones indicated in Fig. 1, the conductivity usually falling as the total amount of alloying material is increased.

Overseas Notes

Civilian Consumption and the War Effort

Decreased civilian consumption, which provided 60 per cent. of America's costs in 1917-18, has contributed little thus far toward meeting the costs of the present programme of war production, according to the Division of Industrial Economics of the Conference Board. Even in the second half of 1941, the volume of production for non-military uses continued at record-breaking levels. Expanded war production during the "defence" period was achieved largely by utilising the previously-unemployed margin of men and machines, and by using equipment to a greater degree of its capacity. The Board's analysis discloses that both Great Britain and Germany are drawing heavily upon civilian production facilities for war requirements. In 1940, the first full year of war, Great Britain obtained from 10 to 20 per cent. of her total armament production by the conversion of civilian facilities, while Germany obtained from 20 to 25 per cent. of her war output by this means. In the last war 60 per cent. of the $31,000 million devoted to war expenditures by the United States is estimated to have been met by reducing the level of civilian consumption. The plan was to bring about gradual curtailment, rather than a sudden extinction of civilian supplies. Severe curtailment of civilian goods was not begun until the summer of 1918.

Employment and Wages in U.S. Steel Industry

Employment in the U.S. steel industry rose during December to 646,000, as against 645,000 in November, according to the American Iron and Steel Institute. In December, 1940, the total was 585,000. Steel payrolls in 1941 were $1,301,348,000, or nearly 35 per cent. more than 1940 payrolls of $960,779,000. Wage-earning employees in the industry earned an average of 99.9 cents per hour in December, compared with 99.0 cents in November and 86.5 cents in December a year previously. Hourly earnings of wage-earners throughout 1941 averaged 95.9 cents per hour, compared with 85.0 cents in 1940. Wage-earners worked an average of 38.2 hrs. per week in December, as against 37.6 hrs. per week in both November, 1941, and December, 1940.

The new blast furnace of the Steel Company of Canada at Hamilton, Ont., is producing about 850 tons of pig-iron per day.

Enough bauxite to meet Australian aluminium requirements for at least 100 years has been discovered in a survey carried out by the Commonwealth Copper and Bauxite Committee, states a report from Canberra.

In the United States, cadmium, frequently substituted for chromium as a rust resisting metal, may not be used after April 1 with certain exceptions. The use of the metal in more than 50 items and categories was prohibited from February 1.

Approximately 9,500,000 tons of finished and semi-finished steel will be exported this year from the United States under lease-lend agreements to Great Britain and her colonies, and Russia and China, principally to the former, according to reported estimates of O.P.M. An additional lease-lend tonnage is understood to be scheduled for Central and South America, with the possibility that a total of 11,000,000 tons of steel may thus be dealt with before next year.

Expenditure by the Canadian Department of Munitions and Supply and its predecessors from July 14, 1939, to June 30, 1941, totals $1,930,814,203. Contracts placed for Canadian account totalled $1,095,844,203. Aircraft production in Canada for the quarter ended June 30 showed a gain of 25 per cent. over the previous three months and was ten times greater than the entire production in 1939. Output for the first six months of this year exceeded the total for all of 1940.

More than $305,000,000 was spent by the American steel industry in 1940 for repairs and maintenance to keep its plants in efficient running order, says the American Iron and Steel Institute. This was nearly 24 per cent. more than the $247,000,000 which was spent in 1939 for similar upkeep. In 1938, these costs totalled $125,000,000. Costs of plant upkeep in 1940 averaged about $6.30 for each ton of finished steel produced during the year, almost exactly the upkeep cost per ton in 1939, when both steel production and the total sum spent on repairs were substantially lower.

Coremaking and Coredrying

(*Concluded from page* 231.)

Mr. C. P. Robinson mentioned an apparatus by means of which the volume of gas evolved from cores bonded with different bonding agents could be measured. In his view much gas evolution indicated insufficient baking and apart from its inconvenience in the foundry tended to create a back pressure in the mould causing misruns. He was referring especially to moulds for very thin castings.

With respect to fine *versus* coarser sands for oil sand work, Mr. Hardy's experience was that the fine sands did not give such a hard outer skin. They tended towards skin cracking during pouring of the mould which caused fin formation, and he had had much trouble from this cause and had overcome it by the use of a coarser sand although the skin on the casting was not so smooth.

Dealing with core irons, Mr. Carrick pointed out the danger arising from irons placed too near the core surface. They heat up, expand and push off the surface of the core. Especially is this the case with long core wires.

Author's Reply

In reply, Mr. Hall said it was quite possible to use sawdust in place of horse manure, and he had done so with success. It was necessary, however, to obtain the co-operation of the core-makers, some of whom view such changes with disfavour and make them serve as excuses for scabbing. Regarding oil-sand fumes, he was in agreement with the remarks made, and considered that, whilst they could be ameliorated, they could not altogether be avoided. Igniting the gases from the vents was one obvious remedy, but, as pointed out by Mr. Hardy, this could not be accomplished if much steam was issuing as well. On the question of fine *versus* coarser sands and efficiency of baking, he referred to a selection of small cores which he had brought for exhibition purposes showing the difference in colour between a properly baked and incompletely baked core.

Mr. Francis thanked Mr. Hall for his able handling of the discussion and the points he had so successfully brought out. There was little doubt that, with more time available, the subject could have been discussed at much greater length.

Nitrogen Take-up of Liquid Iron

Studying the take-up of nitrogen by molten iron under a slag cover, T. Kootz, according to his Paper in the "Archiv für das Eisenhüttenwesen," has found that the solubility-time curve is first steep and gradually flattens. The experimental solubility curves found can be very closely represented by an exponential function. The solubility of nitrogen in pure iron at 1,600 deg. is determined to be 0.046 per cent. As the temperature rises, the amount of nitrogen dissolved increases slowly and rectilinearly. The solubility varies with the partial pressure of the nitrogen. Carbon and phosphorus cause a marked reduction in the solubility and roughly in proportion to the amounts of Fe_3C and Fe_3P present. The formation of gaseous carbon monoxide in the iron also causes a marked expulsion of nitrogen. Chromium much reduces nitrogen solubility. The nitrogen take-up coefficient k increases with thempertaure and falls as the percentages of C and P rise. In the Fe-Cr system, k rises very markedly up to 10 per cent. Cr, then drops again as the Cr is further raised, finally reaching a value of 0.05.

Deliveries of Lake iron ore in the 1941 season totalled 79,281,279 gross tons, and compare with former full season peak of 66,672,881 tons in 1916. Ore consumption in the first ten months of last year totalled 62,772,674 tons, comparing with 61,791,650 tons during all of 1940 and only 872,924 tons under the record ore used during all of 1929, according to the Lake Superior Iron Ore Association.

Coremaking and Coredrying*

THE POSITION IN GENERAL JOBBING FOUNDRIES

By GEORGE HALL

A subject such as this, to be dealt with fully, would involve a very lengthy Paper. Modern foundry practice and the progress of repetition production have divided foundries into several groups. There is the general jobbing foundry, the repetition or mass production foundry, the high-duty and special alloy foundry and the steel foundry.

When a specialised foundry is laid out, there is generally a laboratory to aid the control of the general policy and materials to be used to produce castings by the quickest and cheapest method. Cores have to be dried by a continuous drying system, their removal from coremaker to core ovens by conveyors, and after the cores are dried and cooled off, generally they go direct to the moulding machines or floor moulds. So whatever may be the individual foundryman's opinion, he may have to waive his methods and give way to some more scientific principles to produce cores satisfactorily from the plant placed at his disposal and to meet the requirements of the work generally.

There are in this country hundreds of what may be termed general jobbing foundries, some large and many of them quite small, but they all have to produce good castings and in keen competition if they wish to exist, and it often rests on the shoulders of the foundry manager to solve the problem, how best to produce his cores in the cheapest and most efficient manner, often without any special plant.

It is with this class of foundry that it is proposed to deal. The foundry generally has quoted for a quantity of castings from blue prints, and until the order is placed, pattern and core-boxes received, no preparations can be made to produce the cores, so, when the foreman gets the core-boxes, he may have to proceed with the production almost at once. The first essential thing to do on receipt of the core-boxes is to compare them with the pattern, decide what is the weight of metal around the core, the most convenient spot to let the gas out of the core, and the particular shape of the core iron (if any) to enable it to be easily taken from the casting in one piece if possible, and so use it over again if required.

In the general jobbing foundry, much depends on the initiative of the coremaker concerning the success of his product. Many wasters are made because the coremaker has only thought of how much bonus he can make, instead of how best to make the core to produce a good casting, and before leaving the coreshop cores should be cleaned and finished up to a reasonable point ready for the moulder. By this is meant that vents should be clearly seen, staples for lifting clearly shown by digging around the top of core down to the staples. Many cores are damaged by moulders having to find the lifting staples by digging at the top of the core and then having to patch or make good. Enough care and thought are not exercised when making core irons for large cores or thin section castings such as are used in electrical work. A reasonable space between the outer edge of the core and the core iron must be left for contraction, and where there is a great risk of fracture from contraction it is always advisable to put fingers around the edge of the cast core-iron. This enables the moulder to have a much smaller main iron and certainly not so heavy. Coke or breeze should be used where possible to fill in the centre of the core, this helps the core to dry quickly and allows the core to contract more freely after casting, and certainly helps the fettler when digging out the core in the fettling shop.

Practical Requirements

To get the best results from a casting point of view, the skin should be firm and solid and yet not hard. Blow holes are frequently caused because of the hard face of the core, and even venting will not always prevent this fault. The permeability of the sand should be the criterion when mixing either ordinary sand or oil sand. If care be taken on this point and a strong open mixture produced, the vent wire can almost be dispensed with. The vent wire is an enemy to the face of a corebox or pattern, and can quite easily be eliminated from nearly every core made.

Generally speaking, two kinds of core sand are sufficient to cover a large range of work. There is the ordinary core sand made up of floor sand, new sand, and either a small quantity of manure, sawdust or dried grass, etc. Modern progress in the foundry has produced the oil sands which are now used to make even very large cores, but oil sand is chiefly used for the small and medium sized core. There is a wide difference of opinion as to what is the best class of sand to use, but in all cases the base must be a sharp silica sand. Many foundrymen favour Leighton Buzzard grades, others insist upon shore or sea sand and river sand. The author has tried all these sands, and has finally standardised on a quarry sand from the heart of Essex. The cost of coremaking material largely depends on the cost of the base sand, next to that is the oil. Undoubtedly the best is linseed oil, but the cost is generally prohibitive for the general run of cores, and there is available from quite a number of suppliers an oil that will give the desired result at much lower cost than linseed oil. Many foundrymen experience difficulty with the green bond of oil sand; this trouble can easily be overcome by adding to the mixture a small quantity of strong natural bonded sand, such as Mansfield or Rayleigh sand. Fair size cores can be made this way and handled whilst green. With repetition work, it is not so important to handle the cores in the green state, because generally shell carriers are made to fit the top half of the core when it leaves the core-box and then placed in the core oven. Where there are perhaps, say, six or twelve cores to make, sand must be supplied to enable the coremaker to lift his core by hand and pass it on to a plate with others—hence the reason for adding a stronger sand to produce the green bond.

A good mixture for green bonded oil sand cores can be made up as follows: 68 lbs. of sea sand or the like; 7 lbs. of Rayleigh sand; 1½ lbs. of powder of the dextrine type, and ½ pint of some crude linseed oil. The whole mixture should be milled for at least 10 min. in a paddle mixer, and personal experience has shown that the best cores are produced from freshly made sand, as this mixture has a tendency to air-dry rather quickly.

Core Wash

There are many kinds of core washes, and a good deal depends on the class of work as to whether the wash must be highly refractory or otherwise. With light section casting just a plumbago wash with a little gum added is sufficient. With heavy sections a good mixture is 50 per cent. plumbago, 50 per cent. mineral carbon, and enough core gum to produce a skin that does not rub off with the hand when dry. This mixture of blacking should be allowed to stand for at least 48 hrs. before using from the time it is mixed.

Core Drying

As one visits the various foundries, many types of stoves are seen, and really it is difficult to make up one's mind which is the best. Personally the author favours the hot-air stove. These are generally fed from an outside furnace with channels for the hot air running through or under the floor of the stove. These channels are generally covered with perforated plates. The stove should also have an outlet shaft with a damper plate to allow the steam from the cores to leave easily, preferably in the roof. If the damper is correctly used, very little heat will be wasted through the shaft.

The question may be asked why preference is given to the hot-air stove instead of the open fire in the stove. There are important reasons: (1) The open fire takes up useful space in the stove, and (2) wherever the fire is placed there is always a tendency to burn cores, and unless protection is given to the cores by covering the sides with sheet iron, much damage is done to the cores by the heat and flame from the coke fire. There is also the danger of cores being "sulphur"-coated, and one often sees when the stove is opened up in the morning, everything more or less is of a whitish colour. This has a tendency to give that hard surface to the core, which may be responsible for many unsightly blow holes in castings after machining.

Small portable stoves should be in every jobbing foundry, where small cores can be easily dried, and so enable the larger stoves to be kept closed over long periods. There are quite a number of different types of portable stoves; the one the author is best acquainted with is the Portway core oven. The author has two of these stoves in use in his foundry and they are both coke fired. Although perhaps more costly, the gas-heated stove is preferable to coke fired. The temperature can be controlled by the supply of gas, whereas with the coke fire the door or damper must be opened to allow the excess heat to escape.

Unless oil sand cores are dried at an even temperature they are not very reliable when placed in the mould; 250 to 300 deg. C. is a good range to adhere to, for thereby the cores will bake with a brown skin.

Coke Oven Carriages

A much neglected tool in the coreshop is the core carriage or trolley; cores are distorted, cracked and even broken, due to the jolting and jarring from the carriage when being pushed in or drawn from the stove. The ordinary bearing or even roller bearings are almost useless because of the heat of the stove. A good stove carriage can be made of cast iron, the heavier the better, in the form of a frame, and the wheels should travel along a flat between two chocks. This does away with the use of oil and the spindle of the wheels cannot seize up. If the rail track is in good condition, a carriage of this type with a heavy load can be handled quite easily by one man.

DISCUSSION

Mr. Francis asked for Mr. Hall's comments on the use of sawdust in the place of horse manure in core sand and whether he could suggest any means of lessening the fumes evolved from oil sand cores during casting.

Mr. W. Hardy said that in his experience no reliance could be placed in the local sands for making oil sand cores; they varied too much from one consignment to another.

Mr. D. Carrick remarked that more fumes were evolved from linseed oil bond alone but less trouble of this nature was experienced from some proprietary binders in which linseed oil formed a part only of the binding agent.

(*Continued on page* 230.)

*A short paper read before the East Anglian section of the London Branch of the Institute of British Foundrymen.

Germany's Mineral Position

BUREAU OF MINES ANALYSIS REVEALS STRONG RESERVES

The position of Germany with regard to production and supply of mineral raw materials vital to war purposes, resulting from an eight-year mobilisation of resources through purchase and aggression, as well as internal effort, is reviewed by the Bureau of Mines in a Report by C. W. Wright.

When one sums up the annual output of minerals, metals, and fuels since 1932 in Germany, and adds to these figures, the output of the areas acquired by Germany during the last two years, the results indicate that Germany to-day is surprisingly well supplied with minerals for essential military needs, states the Report. In some instances such as bauxite, aluminium and magnesium, recent production has been greater than the combined output of the United States, Great Britain and Canada, but Germany lacks certain essential minerals such as tungsten, tin, copper, molybdenum, asbestos, and particularly petroleum. However, as Germany has been preparing for the present war since 1933, large quantities of these latter minerals were bought and stock-piled. She realised from the start that to be powerful, a nation must secure the required minerals and metals either by increase in production from domestic sources, by purchase, or aggression. Germany has utilised all three of these methods to a marked degree.

Handicapped by a deficiency of raw minerals that could be profitably mined, Germany first proceeded to develop low-grade deposits of iron and copper, and built up her mineral production regardless of cost. Examples of this are the pig-iron production at the Hermann Goering Works near Salzgitter, and the increased production of copper at the Mansfeld mines at a cost estimated to be over double the world price. Since 1933 Germany has bartered with the Balkan States for most of their mineral output and built up large stocks by imports from the Western Hemisphere. The large increases in mineral imports since 1933 demonstrate that Germany began preparations for the present war some eight years ago. Germany's greatest increase in mineral supply, however, has been through the occupation first of Poland, then Norway, then France, the Balkans, and later of the Ukraine and Donetz Basin. Reports indicate that no time is being lost by the Germans in these occupied countries in organising mineral production in order to get the utmost benefit out of these new sources of supply.

Task of the Allies

There is a general belief in the United States that with America's great mineral resources and plant capacities, it is only a matter of time when the United States, together with Great Britain, will have control of the air and sea. While this is true, it should be remembered that the New Germany already is a powerful adversary working at maximum capacity in the output of airplanes, submarines, tanks, and munitions. Just when the United States and Great Britain will be in position to exceed the German production of these war machines depends largely on their ability to increase and maintain mineral production and the extent to which civilian consumption is curtailed to permit more rapid advances in the manufacture of required war materials. Substantial progress along this line has been made since Pearl Harbour, but a large part of American mineral production is still consumed for non-defence purposes.

Another factor assisting Germany's war effort is the regimentation of labour and industry. As early as 1936 all labour unions had been placed under Government control, and labour was working 60 hrs. a week. Those who obstructed the Reich's labour programme were sent to concentration camps. During the last decade Germany has built up efficient management in all branches of her industries with full control over supplies and labour. Research laboratories are turning out improved weapons and their technicians and engineers are making the most of the mineral resources in the occupied areas. Besides the temporary advantage of regimented industry oriented solely to war objectives, Germany has another great advantage over her adversaries in her ability to deliver tanks, ammunition, and airplanes to the actual fighting lines in greater quantity by reason of direct and comprehensive transport facilities and at much less risk.

Table I gives an estimate of the production in 1940 of German-controlled and supplying countries, which include Germany-Austria, Poland, Belgium-Luxemburg, France, the Netherlands, Norway, Sweden, Finland and Estonia, Czecho-Slovakia, Hungary, Rumania, Bulgaria, Yugoslavia, Greece, Italy, Switzerland, Tunisia, Algeria, Morocco, Ukraine and Portugal. The latter is included because a substantial output of tungsten and antimony goes to Germany. The table does not include iron ore, copper, lead, zinc and mercury from Spain, or chromite, copper, zinc and antimony from Turkey. The inclusion of Spain would raise the percentage control figure for mercury to about 80.

Coal and Iron Ore

Coal output in German-controlled areas is about one-half of the world's production or more than sufficient for all purposes, particularly in the manufacture of coke for use in blast furnaces. In 1940, 46 per cent. of the world's iron ore output was produced in the countries now controlled by Germany. Germany has occupied the iron mines of Krivoi Rog in the Ukraine, said to contain a billion tons of high-grade ore and to have an annual production of about 18 million metric tons. This new source of supply, if held, together with the high-grade ores from Sweden and the enormous deposits of Lorraine, in France, provide Germany ample raw materials to supply the requirements of her steel plants.

German-controlled areas accounted for 44 per cent. of the world's output of pig-iron in 1940. It is probable that the blast furnaces in the Ukraine have been destroyed by the retreating Russians, and it may take a year to rebuild them. Nevertheless, Germany is well supplied with all of her essential pig-iron requirements from the blast furnaces within her borders and the adjoining areas in France and Belgium.

Light Metals

Aluminium.—In 1933 the United States output of aluminium was more than double that of Germany, but in 1940 it is estimated that Germany produced 240,000 metric tons, against 187,000 tons in the United States. Aluminium production in German-controlled countries, France, Italy, and Norway, and also in Switzerland, in 1940 was 15 per cent. greater than the combined output of the United States, Canada, and Great Britain, and amounted to 47 per cent. of the world total. A recent survey shows that the aluminium plants in German-controlled Europe will have a total capacity of 560,000 tons by the end of 1941, compared with approximately 580,000 tons in the United States, Canada, and Great Britain. By the end of 1942 or early in 1943 the production capacity of the latter countries should exceed 900,000 tons. No data are available on Germany's expansion programme.

TABLE I.—*Estimated 1940 Production in German-Controlled Countries.*

Commodity.	Unit.	German-controlled output.	World output.	Per cent. controlled by Germany
Coal ...	1,000 tons	641,286	1,360,000‡	47
Iron ore ...	1,000 tons	100,230	216,675	46
Pig iron ...	1,000 tons	49,105	113,000	44
Mn ore ...	1,000 tons	1,438	5,250	27.5
Chromite	1,000 tons	121.5	1,210	10
Tungsten 60 per cent. WO_3)	Tons	2,736	25,520	11
Nickel ...	Tons	3,350	130,000	2.5
Copper ...	1,000 tons	149	2,200	7
Zinc ...	1,000 tons	597	1,800	33
Lead ...	1,000 tons	433	1,750	25
Antimony	Tons	6,370	34,000	19
Bauxite ...	1,000 tons	2,191	4,400	50
Aluminium	1,000 tons	380	800	47.5
Magnesium	1,000 tons	28.2	42.5	66
Mercury ...	Tons	2,507	6,000	42
Mo ore ...	Tons	1,440	21,220	7
Petroleum, etc. ...	1,000 bbls.	78,507	2,250,378	3.4

‡ 1939 estimate.

Bauxite.—Germany is amply supplied with this raw material essential to aluminium manufacture. The extensive bauxite deposits in France, Italy, Yugoslavia, and Hungary are situated in a much more favourable position for transport to the aluminium reduction plants than those from which the aluminium plants in the United States and Canada get their supply (principally Surinam and British Guiana). Present output in Europe is 50 per cent. of the world's production, whereas the Western Hemisphere contributes only 38 per cent. Both regions have large reserves from which additional production can be obtained although the Western Hemisphere is at a disadvantage because of the transportation problem.

Magnesium.—No official production figures are published in Germany on magnesium output and estimates vary from 18,000 to 60,000 metric tons per annum, the most recent being 40,000 tons for the German-dominated areas. In 1940 the combined British-American output was only 12,000 tons. Large plants are under construction in the United States and by the end of 1941 production of this light metal in the United States and Great Britain will be at the annual rate of about 40,000 tons. By the end of 1942, or early 1943, the United States alone is expected to have a production capacity of 180,000 tons.

Non-Ferrous Metals

Manganese Ore.—Germany's shortage of manganese ore was becoming serious but by the occupation of the Nikopol mines in the Ukraine she has acquired an adequate source of supply, with an annual output of 1,200,000 metric tons, or nearly double that of the Western Hemisphere. The areas now tributary to Germany produced 27.5 per cent. of the world's manganese ore output in 1940.

Chromite.—Within the German-occupied countries the production of chromite in 1940 was 10 per cent. of the world's output. Presumably this production is inadequate to meet German needs. Recent agreements with Turkey included provisions for increasing chromite shipments to Germany. This together with stocks on hand will probably meet all necessary requirements during the next few years.

Molybdenum.—Germany's lack of tungsten is being compensated in part by molybdenum, of which there were large imports for stockpiling in recent years. The increased use of molybdenum in steel alloys, in wires for electric furnace windings, and to replace platinum points in electric contact devices and spark plug points, makes it an essential metal in the manufacture of war machines. Germany now controls about 7 per cent. of the world's output, which, together with stockpiled supplies, should meet all vital military needs for some time.

Nickel.—Nickel is another metal produced only in small quantities in the German-controlled countries, Norway and Greece being the principal producers. Although a heavy importer in past years, her present supply is small. However, if Germany can exploit the recently developed nickel deposits at Petsamo in Finland, an important source of supply will be available.

Tin.—There are no important tin mines in Europe, and Germany formerly depended entirely on imports from the Far East and Bolivia for her requirements. Germany is believed to have had large stocks in 1938 and to have acquired additional stocks in Holland. Germany has developed substitutes for many uses, such as in the food-packing industries, and all available tin is reserved for highly essential applications. Germany has been outstanding in the reclamation of scrap tin and other metals for many years. Cadmium, a substitute in some uses of tin, is produced in substantial amounts in Germany and Poland.

Tungsten.—This is one of the few essential mineral products not produced in sufficient quantity within the new German-controlled area. Germany's nearest source of supply is in northern Portugal, which district shipped only half of its output to Germany in 1940. Germany's requirements are over twice the amount now obtainable, but because imports were exceptionally large during the years preceding the war, amounting to over half of the world's production in 1938, reserve stocks probably are available. Moreover, Germany apparently stockpiled large tonnages of molybdenum, a substitute for tungsten, in the pre-war years.

Copper.—Germany's annual copper consumption reached 300,000 metric tons in recent years, judging from imports and production. Germany and Austria produce probably less than 40,000 tons, so that a large deficit exists. With control of the Bor mines in Yugoslavia, and the exports available from Spain, Norway, and Sweden, Germany's

(*Continued on page* 234.)

Melting in the Electric Arc-Furnace*

SOME METALLURGICAL AND ECONOMIC ASPECTS

From the cost standpoint, the most important period in the electric-arc furnace cast to cast cycle is the melting, during which 70 to 80 per cent. of the total power is consumed, states Norman F. Dufty, in an analysis of some metallurgical and economic aspects of electric furnace melting. Costs can be lowered by increasing the refractory life and the refining time can be curtailed if the furnace is worked efficiently and intelligently. For the purpose of this article, only the modern basic furnace of the Héroult type using three-phase 50-cycle alternating current and melting with full or partial oxidation will be considered.

Refractories

A low-grade refractory will affect the costs not only by raising the refractory cost per ton of steel, but by limiting the length of arc that can be employed. This will lower the melting efficiency by forcing the melter to drop the voltage, thus shortening the arc before completely melting the scrap off the banks. A suitable lining is, therefore, necessary, so that full advantage can be taken of the available power.

Silica bricks have many advantages for roof construction. They are cheap, have a high refractoriness-under-load, resist high-temperature spalling and have a slight after-expansion. The principal constituents of silica bricks, quartz, tridymite and crystoballite undergo allotropic changes accompanied by varying volume changes at comparatively low temperatures. Careful heating is, therefore, necessary.

Although a basic roof is the ultimate ideal in a basic furnace, basic bricks are not normally used, mainly because they are expensive and have a definite after-contraction. Stabilised dolomite and magnesite tend to spall, and chrome-magnesite fails by bursting due to iron-oxide absorption, but metal-cased magnesite seems to offer distinct possibilities. High-duty firebrick and sillimanite are used to a limited extent, usually when intermittent working makes a high-spalling resistance imperative.

Silica, chrome, chrome-magnesite, metal-cased magnesite, stable and unstable dolomite all enjoy varying degrees of popularity for side-wall construction. Silica bricks are satisfactory on older furnaces where low voltages only are used. A high voltage gives a long arc and there is a severe cutting action at the top of the banks, often undermining the upper portion of the wall and causing it to fall in. Thick cooling pipes can be embedded in the wall at the danger points, but the use of a more suitable brick is a better solution.

Magnesite and stabilised dolomite both suffer from spalling troubles and are expensive on a cost-per-ton basis. In addition, supplies of the former are greatly restricted in wartime.

Chrome bricks can be used only in furnaces making steels containing appreciable amounts of chromium because any pieces falling into the slag will result in chromium pick-up in the steel due to the reduction of chromic oxide by the reducing agents in the refining slag. The same thing applies to a less extent to chrome-magnesite bricks and the bursting tendency, due to iron-oxide absorption, is always present.

For long life and ability to stand up to high temperatures, metal-cased magnesite is the best choice for side walls. The metal case oxidises and combines with the magnesium oxide to form magnesio-ferrite and the gradual transition from metal to magnesio-ferrite gives a good low to high temperature bond and spalling is eliminated. Lives of over 300 heats have been experienced in furnaces of 30 to 35 tons capacity, using melting voltages in the region of 250. If metal-cased magnesite is unobtainable, unstable dolomite is a satisfactory substitute if care is taken to store the bricks in a warm, dry atmosphere. The recent development of monolithic dolomite linings shows great promise.

In Britain, furnace bottoms are made almost exclusively of rammed dolomite with magnesite bricks beneath. There is no logical reason why magnesite cannot be partially or wholly replaced by dolomite, chrome-magnesite or chrome bricks, especially in wartime. The use of dolomite mixtures graded to give a high packing density is on the increase, and is proving a definite advantage. Bottom damage due to electrode boring, a trouble which increases with the melting voltage, is minimised. A bottom of this type is easy to keep in good repair, an important point in quality steel production.

Furnace Design

Furnace design greatly affects refractory life and melting time. Given the same type and thickness of refractory, the maximum economic power input and, therefore, the melting efficiency will be lower and the refractory costs will be higher on a badly-designed furnace.

The main fault with the earlier furnaces was that the roof was too low, bringing the silica bricks with which it was built near to the arc. This made little difference when low voltages of the order 80 to 100 were used, but when higher voltages became popular, roof life decreased, owing to the close proximity of the longer arc. Thicker roofs are normally used in European practice than in America, probably because of the relatively higher price of silica bricks in that country.

Sloping side walls are being developed in Russia and America. This improvement counteracts the under-cutting tendencies of the silica side walls. When basic bricks are used and silica drip from the roof normally causes erosion, the thickness of the top of the wall may be increased without overbalancing.

Careful positioning of the electrode centres is important. If they are too widely spaced, the side walls suffer and if put too close together, the roof centre is weakened, and it is difficult to melt the scrap off the banks. In either case, premature reduction of power input is necessary.

The rotating hearth is another recent innovation which has given good results. An arc of 30 deg. each side of the vertical is made by manual control during the melt and automatically during refining. Although there is no concrete evidence that this is an advantage during refining, the more uniform heating of slag and metal must be beneficial in some degree. Melting is commenced with the shell rotated 30 deg. to the left, when the electrodes reach the bottom they are raised and the shell turned 120 deg. to the right. After again boring to the bottom, the shell is turned back to the centre position. In this way nine holes instead of three are bored in the charge. Also any small areas of unmelted scrap which often cause delays of 15 min. or more, can quickly be liquidated by moving the shell around until the offending piece is as near to the arc as possible. Time savings vary from 25 to 30 min. on a 20-ton furnace rated at 6,000 k.v.a. to 15 to 20 min. on a 10-ton furnace rated at 4,500 k.v.a.

Charging

The type of scrap used and the manner in which it lies in the furnace are two factors which exert a profound influence on the melting time. Arc-furnace scrap usually varies from turnings to ingots, blooms and similar heavy pieces.

The means of charging are as follow:—(1) Top charging, *i.e.*, removable roof or bath run-out using a drop-bottom bucket or similar device. The "coffee-pot" type in which the roof and electrodes are swung back, the axis of movement being horizontal, has been abandoned as the strain on the electrode gear and roof refractories was too great on all but very small furnaces. The lift-and-swing-aside and roof run-out designs are quite efficient, but a bath run-out places less strain on the roof bricks and the complicated electrode travel mechanism is not disturbed.

(2) Machine charging has certain advantages. Capital cost of the furnace is lower if top-charging is not provided for, and precise placing of the charge is easier. However, the charger damages the door jambs and the refractory costs are increased; furnace repairs cannot be carried out so easily and production is hampered by the slower charging. (3) Hand charging is practised only on small furnaces where the low throughput does not warrant the increased capital expenditure necessitated by other methods.

The same arrangement of charge should be maintained whether the scrap is placed in the furnace by the charger or in the charging basket by the magnet. A layer of turnings is placed on the bottom to reduce abrasion which the sharp corners of any heavy pieces may cause. These heavy pieces and ingots, etc., are charged next and placed in the furnace as low as possible to reduce the chance of electrode breakage which may occur when the scrap begins to fall as melting proceeds. The lighter scrap is then charged with turnings on top. In this way the arc is struck easily and soon buries itself in the scrap, so protecting the roof. If no light scrap or turnings are available, it is advisable to start melting on an intermediate voltage tapping and go on to the highest tapping, when the arc is well buried. Particular care should be taken with scrap which has a high packing density. If punchings, for example, are charged on the bottom, they tend to weld together, the charge melts from the top downwards and difficulty is experienced in lifting the scrap off the bottom.

In top-charged furnaces it is an advantage to put lime, say, ½ cwt. per ton of scrap, between the walls of the furnace and the charge after placing the scrap in the furnace, but before levelling off. This prevents abrasion of the walls and aids slag formation in the early stages of the melt. The lime holds the scrap off the walls and a space is provided into which long hooks can be inserted when pulling in off the banks.

As soon as possible the scrap is pushed away from in front of the door and a fracture sample is taken to indicate the carbon content of the bath. A good carbon boil during the melt is advantageous, both metallurgically and economically. The metallurgical advantages will not be dealt with here. A lively boil will prevent undue reflection of heat on to the walls and roof. This enables a higher power input to be continued for much longer than if there is a deficiency of carbon or oxide in the bath. If there is a lack of oxide, the slag is heavy, unreactive and reflective; if there is a shortage of carbon, the slag is thin and fiery, attacking the banks chemically as well as reflecting the heat.

The carbon boil has been studied in great detail chemically by numerous investigators, but the subject has not yet been thoroughly examined from the physical point of view. Körber and Oelsen have established that, even when the CFeO product is many times its equilibrium value, a boil does not commence if the furnace bottom is smooth and glazed over. Larsen has recently expressed the opinion that a rough surface, such as a dolomite bottom, contains voids too small to be filled by the metal on account of its surface tension. The reaction product, CO, diffuses into these spaces and bubble formation is promoted. As these bubbles rise through the metal, more CO diffuses into them and the reaction becomes autocatalytic. It often happens that there is a con-

* From an article in "Metal Treatment" by Norman F. Dufty.

Electric Arc-Furnace Melting

siderable amount of unmelted material left on the bottom. This semi-fused mass does not present a surface favourable to bubble formation. Although there is plenty of carbon in the bath and ore is added, a free boil does not result until the CFeO product has built up high enough to overcome the inhibiting effect of the glazed surface. When this does occur, there is a violent boil, usually lifting the remainder of the scrap and often causing the loss of slag and metal over the sill. The bath is generally cold and over-oxidised after this boil has subsided. The addition of lumpy ore to penetrate the slag and initiate a boil is recommended; a small addition of ferro-manganese or spiegel will have a similar effect and guard against over-oxidation.

Power Input

The maximum economic power input for melting depends on several factors, such as refining time, M.D. charges, the possibility of working during off-peak periods only, etc. The longer the refining time, the longer the transformer capacity will be lying idle. The melting time divided by the refining time can be taken as the utility factor (U.F.).

(*a*) 15-ton furnace, 4,000 k.v.a., 267 k.v.a. per ton; melting time, 2½ hrs.; refining time, 4 hrs.; U.F. 0.625.

(*b*) 7-ton furnace, 2,300 k.v.a., 325 k.v.a. per ton; melting time, 2½ hrs.; refining time, 2½ hrs.; U.F. 1.0.

(*c*) 15-ton furnace, 11,000 k.v.a., 734 k.v.a. per ton; melting time, 50 min.; refining time, 30 min.; U.F. 1.66.

(*d*) 8-ton furnace, 3,500 k.v.a., 440 k.v.a. per ton; melting time, 1½ hrs.; refining time, 5½ hrs.; U.F. 0.272.

Examples (*a*) and (*b*) are fairly representative and show that the furnace with the highest k.v.a. per ton figure does not always have the lowest U.F. Example (*c*) and (*d*) are more extreme; (*c*) is a very powerful furnace working two 8-hr. shifts during the off-peak period and making basic open-hearth quality steel under an oxidising slag. Low capital cost per ton of output and a favourable power tariff enable such steel to be produced at competitive prices. Furnace *d* has a fairly high power input, but the disproportionally long refining time cuts the U.F. down to the very low figure of 0.272.

The inherent resistance of the furnace installation, *i.e.*, the ohmic and inductive resistance of the transformer and low-tension leads, is not usually enough to damp the inevitable current surges sufficiently. Any additional resistance will be inductive so as to reduce the energy losses as much as possible. As the ohmic resistance is small compared to the inductive resistance, it can be said that the reactance of the circuit determines the magnitude of the surges and also cos ϕ (the power factor).

Taking a typical installation and considering the inductive resistance only, it was found that the power factor was 0.70 and the surge 140 per cent. of the rated current. As the arc power decreases with cos ϕ, it was advisable to operate with a power factor of 0.80 to 0.90. The surges corresponding to this reactance were 80 to 90 per cent. above the rated current, but were not considered to be too high, especially as the ohmic resistance of the leads, transformer and charge would bring the actual maximum lower than the calculated maximum. In modern furnaces the reactance in circuit is usually automatically increased when the voltage is raised. It would probably be better to provide an external reactor with three or four tappings. This could be cut out of the circuit once a level bath was obtained and the tapping to be used during the melt would depend on the nature of the charge, and the decision is best left to the foreman or melter in charge of the furnace. Sometimes it is an economic advantage to use a condenser to improve the power factor without increasing the peak surges.

Equipment

Either graphite or amorphous carbon electrodes can be used. Although costing three times as much as amorphous carbon, the consumption figure in lbs. per ton of steel for graphite is only 25 per cent. of that for amorphous carbon. Compared with amorphous carbon, graphite has a 17 per cent. higher sp. gr., less than a quarter the specific resistance, will carry two and a half times the current, has an oxidation temperature 125 deg. C. higher, and has more than double the thermal conductivity. The larger ports necessary for amorphous carbon electrodes weaken the roof and transport costs and breakages are often excessive. Much depends on the situation of the furnace relative to the source of supply and the size of the furnace. The present trend is towards higher-powered furnaces, and this may account for the fact that most steelmakers prefer graphite.

The higher melting voltages in use to-day make operating conditions very severe for the conventional oil-circuit breaker. Frequent surges of varying magnitude have to be accommodated and a heavy charge will cause the breaker to open on overload many times during the melt. Even when the electrodes are run up before tripping the switch for tap changing, the magnetising current of the transformer has to be broken and some arcing takes place. The oil is thus quickly contaminated, and in these days of maximum production it is not always possible to change the oil as often as it should be changed. The air-blast circuit breaker has not this disadvantage and after being successfully used in other fields, is now being used on some of the latest arc furnaces. In Continental practice, the use of the normal works compressed-air supply is favoured, but it is much safer to have an individual compressor, and the works' supply can be used as a stand-by.

Efficient automatic control cannot eliminate peak loads, but can reduce their duration considerably. The length of the arc is governed by the voltage, current and furnace atmosphere. During the melt it is essential for the electrodes to be moved to the correct position after a fall of scrap so that the arc power can be maintained at the correct figure. The control is normally operated by electromagnetic relays in accordance with the current setting. Power $= EI\sqrt{3}\cos\phi$, E is invariable and there is a definite relation between I and cos ϕ. Both electric and hydraulic movements are in use, but the latter tends to cause the electrodes to "float," so the former is deservedly becoming the most popular. Some types of electric control are designed so that the speed of movement is proportional to the instantaneous deviation of the current; in this way "hunting" is reduced to a minimum.

Concluding, the author gives the following rough specification for a 30-ton furnace:—Dia. at foreplate, 16 ft.; foreplate to roof, 5 ft.; side walls, 10 deg. slope to vertical; roof, 14-in. silica brick; side walls, 18-in. metal-cased magnesite backed by 3-in. insulating brick; bottom, 12-in. rammed graded dolomite, 9-in. stabilised dolomite brick, 4½-in. magnesite brick, and finally 4½-in. insulation; electrodes, 18 in. dia. graphite; electrode centres, 40 in.; rotating hearth 60 deg. each side of the centre line; bath run-out for basket charging; transformer, 10,000 to 11,000 k.v.a.; low-tension tappings, six, 100 up to 240 volts; maximum current, 25,000 amps.; air blast breaker with individual compressed-air supply, works supply as reserve; reactor, external, independently operated with tappings at 10, 20, 30 and 40 per cent.; electrode control, electric. This furnace should give a tap to tap cycle of 4½ hrs.; a melting time of 1¼ hrs., and an output of approximately 1,000 tons of constructional alloy steel per seven-day week.

Specification Notes

Ferrous Pipes and Piping Installations:—A new British Standard for ferrous pipes and piping installations (B.S. No. 806—1942) applies to the construction of the pipework connecting a land steam boiler to engine, turbine or industrial plant and all auxiliary pipework in connection therewith, together with the individual pipes and pipe fittings forming parts of such installations for:—(*a*) Pipes of any bore where the pressure exceeds 50 lbs. per sq. in.; (*b*) pipes over 10-in. bore for steam at pressures of 50 lbs. per sq. in. and below. The specification does not apply where temperature exceeds 900 deg. F. In determining the maximum working stresses to which pipes may be subjected, the various physical properties of the pipe material have received attention. Copies of this new standard may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1. (Price 3s. 9d., post free.)

Aluminium and Aluminium Alloy Specifications: The first edition (October, 1940) of this booklet, which was a fully classified summary of current D.T.D. and B.S. Specifications relating to aluminium and aluminium alloy products, was compiled by the technical staff of the Northern Aluminium Company, Limited. During the last twelve months many specifications have been cancelled or modified by the authorities and the new edition of the booklet includes all relevant alterations issued up to the end of November. To simplify the presentation of these changes, all specifications cancelled in recent years have been included in the numerical index, with a note of the reason for cancellation given by the publishers. The form of presentation remains unchanged in the new edition. Copies of this publication may be obtained free of charge from the R. and D. Department of the Northern Aluminium Company, Limited, Banbury.

Zinc and Brass Die Castings for Aluminium:—The possibility of using zinc and brass die castings instead of aluminium in the manufacture of artillery fuses was recently discussed by the Technical Sub-Committee of the U.S. Defence Industry Advisory Committee for the Die Casting Industry. Aluminium castings are vital in the aircraft industry, and the use of less critical metals in making artillery fuses will result in a substantial aluminium saving. Brass, steel and zinc castings already are being used in some fuses, but it is likely that more extensive substitutions can be accomplished. The change from aluminium to either brass or zinc affects ballistic properties, and in an accurate mechanism such as a fuse, failure to function properly might result in serious consequences. Samples of brass and zinc castings have therefore been made and subjected to extensive tests prior to actual use.

Boiler Scale and Fuel Wastage

The loss in boiler efficiency, due to scale or incrustation, runs approximately as follows, states "Coal Heat":—

Thickness of Scale	Loss of Efficiency	Coal Wasted per Ton
$\frac{1}{32}$ in.	7.2%	144 lbs.
$\frac{1}{16}$ in.	11.1%	222 lbs.
$\frac{1}{8}$ in.	12.4%	248 lbs.
$\frac{1}{4}$ in.	15.9%	318 lbs.

Germany's Mineral Position

(*Continued on page* 232.)

position has been improved. In 1940 German-controlled countries (not including Spain) accounted for approximately 150,000 tons or about 7 per cent. of the world's output of copper. Large stocks of copper are said to have been acquired in France, Belgium, and Holland, and estimates indicate that Germany will have a sufficient supply for essential military needs for the immediate future. Every effort has been made in Germany to replace copper with plastics, aluminium, and other metals.

Lead and Zinc.—The occupation of the lead-zinc districts of Upper Silesia, Poland, and Trepca, Yugoslavia, has greatly increased Germany's supplies of these metals. Italy is also a large contributor, and Tunisia and Algeria likewise produce substantial quantities. Thus both in lead and zinc, Germany controls sufficient production to meet her requirements.

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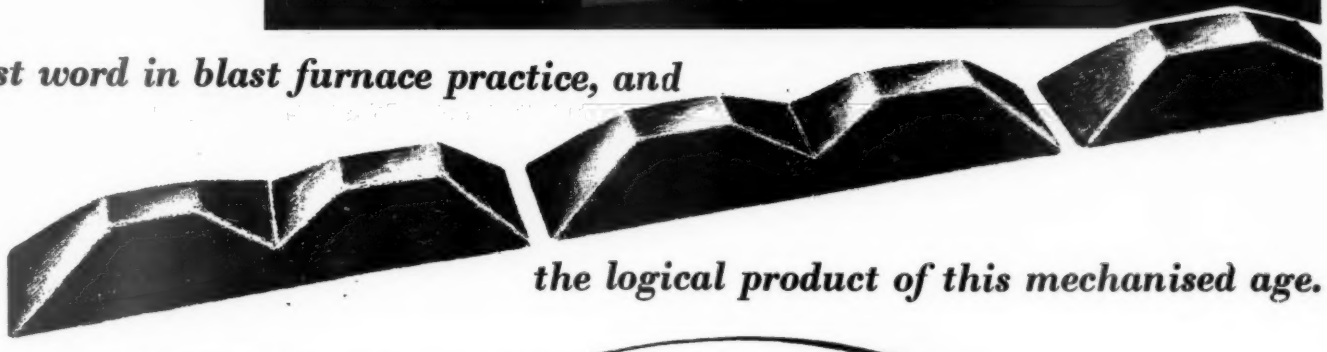
Last word in blast furnace practice, and



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The Week's News in Brief

Trade Talk

THE FIRM of Pattison & Hobourn, Limited, of Coventry, general engineers, has changed its title to Hobourn Aero Components, Limited.

HALF THE POPULATION of Britain are now directly on national service. The Minister of Labour stated last Saturday that he has mobilised into the Navy, Army, R.A.F., Civil Defence or munitions 20,000,000 out of 40,000,000 people.

THE ANNUAL MEETING of the Institution of Mechanical Engineers on April 24 will commence at 5.30 p.m., and not 6 p.m., as previously advised. A Paper, "A Review of Recent Progress in Heat Transfer," will be presented by Prof. C. H. Lander, C.B.E., D.Sc., M.I.Mech.E.

THE JOINT CONSULTATIVE COMMITTEE, consisting of the British Employers' Confederation and the T.U.C., at a meeting at the Ministry of Labour last week, agreed that workers who in the present emergency are employed part-time should, in general, be excluded from the scope of the Essential Work Order.

THE GREAT WESTERN RAILWAY recently carried to the North from a large works near London a steel steam-hammer block weighing 85 tons and measuring 12¼ ft. long, 8 ft. broad, and 6 ft. thick. For this purpose the G.W.R. employed their 24-wheeled girder wagon, built with interchangeable centre sections to suit vari-shaped loads. It weighs 82 tons and can carry up to 120 tons. Representing a contribution in the campaign for the collection of iron and steel scrap, this large block was safely, and without incident, transported to its ultimate destination.

MR. A. A. JAMIESON, chairman of Vickers, Limited, in his statement accompanying the accounts, points out that the figures in the balance-sheets of Vickers-Armstrongs, Limited, and the English Steel Corporation, Limited, showing the work in progress, give some indication of the great productive contribution which this group of companies is making to the war effort. The figures, large as they are, do not include the work in progress at the shadow factories which they manage on behalf of the Government or at the works of the many companies other than the two mentioned, which are owned or controlled by Vickers, Limited. The number of employees grows month by month and the percentage of women among these tends steadily upwards.

THE MINISTER OF LABOUR has now made a direction under Art. 4 of the Undertakings (Restriction on Engagement) Order, 1941, enabling employers in undertakings covered by the Order to make direct engagements of women above the age of 30. Such women are similarly permitted to secure employment direct. The Undertakings (Restriction on Engagement) Order has till now prohibited the engagement of labour irrespective of age in building, civil engineering, contracting, electrical installation and general engineering undertakings otherwise than through an Employment Exchange or an approved trade union arrangement. The Employment of Women (Control of Engagement) Order controls the engagement for employment of women between the ages of 20 and 30 in practically all other industries. The effect of this Direction will therefore be to put employers in undertakings covered by the Undertakings (Restriction on Engagement) Order in the same position as employers in other industries which are covered by the Employment of Women (Control of Engagement) Order in the matter of the engagement of women over the age of 30.

CRITICISMS WERE SOMETIMES MADE that output was affected either by the fault of Government purchasing departments, or by errors of works management, or by slack working and absenteeism on the part of those employed, said Lord Aberconway at the annual meeting of Thos. Firth & John Brown, Limited, last week at Sheffield. Government departments might and indeed must of necessity make changes in the type of products ordered, but in their case these changes had been made in consultation with the management, and had in no way diminished the production. The company's staff had organised an output larger than anyone three years ago would have believed to be in any way possible. The company's employees had worked most strenuously, and absenteeism had been remarkably low. Speaking for the steel and engineering trades, he would say that such criticisms, founded very often on isolated trades or trivial cases, and unless strictly confined to such trades or cases, were unfair to and were much resented by men, whether Government officials, managers, or workpeople, who were doing, and doing most successfully, their very best to carry on the work entrusted to them.

PRESIDING AT THE ANNUAL MEETING of Richard Lloyd & Company, Limited, Mr. Evan Ag. Norton (chairman) said that because of income-tax, E.P.T., and certain charges, such as war damage insurance, which were not admissible as deductions for tax purposes, every year the surplus of profit, over and above that required to pay the dividend, had become smaller until it threatened to reach a figure which was inadequate to secure the future prosperity of the company. Provision had been made for the repayment at some future date of 20 per cent. of the Excess Profits Tax, but the terms in which that concession was couched were not sufficiently definite to enable them to look forward with any confidence to the repayment of this money. He urged that the position should be clarified so that industry as a whole might have, in return for the heavy contribution which it was now called upon to make, the guarantee of some financial assistance from the Government to help it through the difficult times which must inevitably follow the war, when they could not hope to compete in world markets unless they had the means to overhaul their plant and equipment and keep it up to date. No such guarantee was to be found in the vague wording of the Finance Act.

Personal

MR. W. D. KENDALL, the Independent candidate, who has been returned as M.P. for Grantham, is the managing director of an engineering works in the Midlands.

MR. KENNETH LAMPSON has been appointed personal assistant to Mr. J. M. Duncanson, Deputy Controller in charge of Iron and Steel Supplies, Iron and Steel Control.

MR. E. E. G. ODDS has been elected a director of Aveling-Barford, Limited, Grantham. He started his business career with Aveling & Porter, Rochester, in 1914, and in his 28 years of service has risen from a junior clerk to a directorship.

COL. E. A. WILSON, of Evered & Company, Limited, Smethwick, was elected president of the Brassfounders' Employers' Association at the annual meeting in Birmingham. He succeeds Mr. F. V. Madeley, who had held the position for three years.

MR. H. W. B. SKINNER, Wills' Research Fellow, and Lecturer in Spectroscopy, Bristol, has been elected a Fellow of the Royal Society "for his work on the X-ray spectroscopy of the solid state leading to results of importance in the theory of the structure of metals."

Obituary

MR. LOUIS THOMAS LEAH, of H. Leah & Sons, Limited, hollow-ware stampers and piercers, Sheffield, died on March 27, as the result of an accident.

MR. GILBERT JAMES SCOTT, chairman of Laurence, Scott & Electromotors, Limited, died suddenly at East Carleton, Norfolk, on March 29. He was 52 years of age.

MR. THOMAS WIGLEY SOMERVILLE, managing director of John Lang & Sons, Limited, lathe manufacturers and ironfounders, of Johnstone, died at his Renfrewshire home recently. He was in his 60th year.

MR. REGINALD ARTHUR BOUCHER-GILES died recently at Wolverley, Kidderminster. He was the founder of the firm of Boucher-Giles & Company, Limited, engineers and agricultural equipment manufacturers, of Birmingham.

MR. WILLIAM CROSHER, chairman and managing director of the Rivet, Bolt & Nut Company, Limited, died at his home in Glasgow on March 30. He was a former chairman of the Black Bolt and Nut Association of Great Britain and present chairman of the British Rivet Association.

MR. JOSEPH MIDDLETON MIDDLETON has died at South Shields at the age of 81. He joined the firm of J. P. Rennoldson & Sons, shipbuilders and engineers, South Shields, in 1876, and eventually became managing director with the late Mr. Charles Ross. The shipyard closed down several years ago.

WE REGRET to announce the death of Mr. H. J. Maybrey, B.A., D.I.C., managing director of the light alloy foundry bearing his name at Sydenham. On leaving school he went straight into the Army, where he attained the rank of captain. On demobilisation he graduated at Cambridge and later did some pioneer research work on magnesium alloys. He was at one time a prominent member of the London Branch of the Institute of British Foundrymen, and only last year renewed his contact by the giving of a most interesting talk on die castings.

Reports and Dividends

(Figures in brackets refer to the previous financial year.)

Switchgear & Cowans—Dividend of 10% (15%).

Dunswart Iron & Steel Works—Ordinary interim dividend of 6% (same).

Quirk Barton & Company—Final dividend of 6%, making 8½% (same).

William Blythe & Company—Final dividend of 10%, making 15% (same).

C. & W. Walker—Dividend of 10% (same) and a bonus of 5% (nil), making 15%.

William Beardmore & Company—Final dividend of 7% for 1941, making 10% (same).

British Oxygen—Final dividend on the ordinary shares of 7% (8%), making 14% (15%) for 1941.

Stewarts and Lloyds—Dividend on the deferred stock of 12½% (same) for 1941, and on the liaison deferred shares a dividend at the same rate relatively as on the deferred stock.

Josiah Parkes & Sons—Trading profit for 1941, £40,438 (£40,583); taxation, £21,964; A.R.P., £2,552; final dividend of 6%, making 10%; to reserve, £5,000; forward, £12,837 (£10,528).

Manganese Bronze & Brass—Net profit for 1941, before reserving £55,805 for taxation, £101,784 £146,857 before £98,500 for taxation); final dividend of 17½%, making 25% (same).

Lanarkshire Steel—Profit after war damage insurance and taxation, £46,149 (£55,231); depreciation, £25,000 (same); supplementary depreciation, £15,000 (nil); to reserve, £5,000 (£20,000); dividend of 12½% (same); forward, £68,176 (£87,439).

Vickers-Armstrongs—Profit for 1941, after tax, £1,931,023 (£1,963,527); depreciation, £1,160,000; net balance, £771,023 (£963,527); ordinary dividend of 5%, tax free (7%, tax free), £393,221 (£550,509); preference dividends, £318,494; forward, £268,896 (£209,588).

Parker, Winder & Achurch—Trading profit for 1941, after depreciation, £71,337; net balance, after £57,000 for taxation reserve, £14,337 (£18,852); preference dividend, £660; dividend on the ordinary shares of 10%, £4,050; bonus of 5%, £2,025; war contingency reserve, £10,000; forward, £16,304 (£18,702).

Vickers—Full report shows:—Profit for 1941, £977,755 (£1,188,651); debenture interest, etc., £68,850; to contingencies reserve, £250,000; dividends on the preference stocks, £312,052; interim dividend of 4% on the ordinary stock, £123,155; final dividend of 6%, £184,732; forward, £690,786 (£651,821).

Applications for Trade Marks

The following applications to register trade marks appear in the "Trade Marks Journal":—

"BLITZBOROUGH"—Vices. FRANK TIPPEN & SONS, 81, Shakespeare Street, Coventry.

"RHODALLIUM"—Alloys of precious metals. HEIMAN PADOVA, 11A, Queen's Court, Queen's Way, London, W.2.

"HIDU"—Metals and alloys. HIGH DUTY ALLOYS, LIMITED, 89, Buckingham Avenue, Trading Estate, Slough, Bucks.

"SHIRO"—Flushing cisterns. SHIRES & COMPANY (LONDON), LIMITED, Norman's Buildings, Central Street, London, E.C.1.

"MOLOBIUM"—High-temperature metal alloys. B.B.H. (LONDON), LIMITED, Upper Downing, Whitford, Holywell, North Wales.

"EDGWICK"—Injection moulding machines and die-casting machines. ALFRED HERBERT, LIMITED, Canal Road, Foleshill, Coventry.

"COMET"—Vices and clamps and machine tools. CHARLES CHURCHILL & COMPANY, LIMITED, Walnut Tree Walk, Kennington, London, S.E.11.

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The provision and maintenance of refractory structures is a substantial item in production costs. The life of refractories is, therefore, of prime importance and is so regarded by the G.R. organisation. To reproduce—by the hundred thousand — refractories which are the nearest practical approach to constant uniformity in quality is no light task. Every process employed in their manufacture is strictly controlled and close attention is paid to their behaviour in service. The success of the G.R. policy in maintaining so high a standard is shown by the world-wide use of G.R. materials and their commendation by engineers in every industry.

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SILICA BRICKS . SILLIMANITE . SANDS

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Raw Material Markets

Apart from the carrying out of essential plant renovations and repairs there was little lost time in the iron and steel industry during the Easter period. In view of the vital part which the industry is playing in the war effort, no extended vacation could be afforded, and at many producing works operations were maintained throughout the week-end. For a long time past plant has been in continuous activity, so that a certain amount of repair work has had to be undertaken; in wartime, however, this is done with the minimum interruption to production, and it is satisfactory to report that outputs have suffered but little through this cause. It is believed that the authorities are contemplating the centralisation of control of all pig-iron deliveries; such a step would be helpful towards economy in transport.

Pig-Iron

MIDDLESBROUGH—High-phosphorus iron is being used more and more extensively in this region, owing to the shortage of better grades of iron. Licences for hematite and low-phosphorus iron for the second quarter of the year are even fewer than for the first period, and it is possible that still further restrictions will be placed on the use of these qualities. Makers of heavy castings normally utilise very little high-phosphorus iron, but the supply position of other grades has made it imperative that alternative descriptions should be used where practicable. Hematite cannot be obtained except in cases where no alternative is available and where the potential consumer is engaged on really important work. The Control has fair tonnages in stock, but, in view of the necessity for curtailing imports of foreign ore, it is essential that these reserves be held for as long as possible. Buyers of ordinary foundry iron are getting most of their requirements from makers in the Midlands and, on the whole, supplies are coming through very satisfactorily.

LANCASHIRE—Demand for foundry iron from makers of light castings and a number of jobbers remains at a comparatively low ebb, with prospects of any material improvement only slight, as few of these concerns are in a position to cater for the needs of Government departments on any scale. Derbyshire and Staffordshire brands of No. 3 pig-iron are arriving regularly to meet the needs of heavy-electrical engineers, machine-tool manufacturers, etc., who are briskly employed on contracts for the Government, and activity in these sections is likely to be accelerated with the coming into production of additional works. Low-phosphorus iron continues to be most difficult to acquire, while Scotch irons and hematite are also only to be had in small tonnages and in special cases when the use of alternative grades would not produce satisfactory results.

MIDLANDS—Northants and Derbyshire high-phosphorus pig-iron is in plentiful supply; consumption is not as large as it might be if the light-castings trade was sharing more fully in the contracts of the various Government departments, but quite a fair quantity is being used by other branches in order to eke out supplies of better quality irons which are rather tight. Hematite, for example, is sparingly distributed, while the amount of low-phosphorus iron released is nothing like sufficient to satisfy all requirements. Thus, refined and high-phosphorus grades are enjoying an inflated demand. In many instances consumers are obtaining excellent results from the changed mixtures, but, where satisfactory results cannot be obtained, the Control authorities permit the use of normal descriptions. The light-castings industry is quite the dullest section in this area, heavy engineers, jobbing foundrymen, and machine-tool makers, in particular, being kept operating on a full-time basis on orders of national importance.

SCOTLAND—Heavy engineering foundries, together with marine engineers, are turning out vast quantities of products needed for the war machine, and business in these departments is at peak levels. Unfortunately, they are not able to secure all the low-phosphorus iron they would like, but high-phosphorus iron is frequently proving a good substitute and ample tonnages of the latter are coming forward, chiefly from producers in the English Midlands. Activity among the light-castings makers in the Falkirk district is variable; some works have well-filled order-books, but, on the whole, there is ample room for improvement. Basic iron for the steelworks is fairly readily forthcoming, but the volume of hematite released by the Control remains very restricted.

Coke

The time of the year is approaching when consumers of foundry coke will concentrate on replenishing their stocks for use later, when deliveries may be less regular. Most of the larger users maintain considerable reserves, while many smaller buyers also tend to purchase in excess of their immediate needs. Supplies are promptly available, stocks at most of the ovens being appreciable. The minimum price of Durham best foundry coke remains at 62s. 9d. per ton, delivered to stations in the Birmingham and Black Country region.

Steel

Production of steel semis during the past quarter has been expedited to a considerable degree, and this expansion of output has reduced the dependence of users on American supplies. Imports have already been lowered, but the Control have quite large stocks on hand for use in emergencies. As additional shipbuilding orders are placed, the demand for sections and plates expands, and makers are well booked ahead. Structural engineers' requirements, too, are fairly heavy for the second period of the year, although the present level of demand may not be maintained indefinitely. A considerable quantity of shell-discard sections is being taken up, thus conserving supplies of ordinary mild steel. Special and alloy qualities of steel are as active as they have been over some months past, Government needs being at a very substantial level. Outputs are fully taxed and every effort is being made to increase production still further.

Scrap

Despite recent improvements in deliveries of many grades of scrap iron and steel to consuming points, there is need for further acceleration in the collection and sorting of old metal, which is playing a major part in war production. There was no suspension of deliveries during the Easter period and licences covering Period 2 involve very large tonnages. Steelworks are particularly heavy consumers of scrap and supplies of some of their qualities are by no means over-plentiful. Iron-foundries, generally speaking, are procuring adequate quantities, but there is an insistent demand for heavy machinery and ordinary cast-iron scrap.

Metals

COPPER—Supplies of copper at the command of the consuming industries in this country are fully adequate to meet the needs of all essential users. Consumption for a long time past has been at record levels and is expected to expand further.

TIN—The conservation of stocks of tin is uppermost in the minds of the authorities at the present time. Urgent requirements are being promptly satisfied, but every effort is being made to reduce the usage of the metal. The specialised knowledge of the Tin Research Institute is being drawn upon by the Government with a view to finding fresh ways in which tin consumption may be brought down to the desired level.

SPELTER—Various economies in the consumption of spelter are being introduced in order to safeguard future urgent requirements. The galvanising of black sheets is now forbidden except under special permit, while a wide range of articles has come under the ban on galvanising. There is no suggestion of a shortage of spelter, but the Control are taking no risks.

LEAD—The quantity of lead in stock in this country must be appreciable, but, even so, distribution of the metal is being tightened up very considerably and it is no longer possible to procure supplies for other than Government orders or important work in civil contracts. The main consumers at present are the cable and battery manufacturers, who have a large volume of Government business on their books.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

542,851 HAYNES STELLITE COMPANY. Method of heat-treating corrosion-resistant nickel-base alloys containing molybdenum.

542,921 FOUNDRY SERVICES, LIMITED, and WEISS, E. Deoxidation of iron and steel.

542,968 TAIT, W. H., and CHALMERS, B. Magnetic apparatus for measuring the thickness of thin layers.

543,021 TITANIUM ALLOY MANUFACTURING COMPANY, KINZIE, C. J., and WAINER, E. Bonded refractories.

543,025 UNITED STEEL COMPANIES, LIMITED, RUSSELL, G. A. V., and JAMES, W. L. Vertical heating furnaces.

543,060 SHORTER PROCESS COMPANY, LIMITED (Linde Air Products Company). Heat-treatment of metal bodies.

543,093 MCCANDLISH, W. H., and SKINNER, A. J. Recuperators or regenerators for the interchange of heat between gases.

543,137 UNITED STATES RUBBER COMPANY. Process for electrodepositing iron and electrolyte therefor.

543,156 LUXFER, LIMITED, BATES, R. E., and BRIDGE, A. Method and apparatus for coating the interior of tubular bodies.

543,178 AKOMFINA AKT.-GES. FUR KOMMERZIELLE UND FINANZIELLE ANGELEGENHEITEN. Alloy steel for casting cutting tools.

543,202 NICOLSON, J. Production of sand cores for foundry purposes.

543,216 STERNBERG, J. DE. Machines for casting under pressure metals having a high melting point.

543,245 WALDRON, F. B. Manufacture of steel.

543,262 HEAD, WRIGHTSON & COMPANY, LIMITED, and LAKE, N. C. Apparatus for de-twisting metal sections.

543,285 SOC. ELECTRO-METALLURGIQUE DE SAINT-BERON. Process for manufacturing in the electric furnace alloys having a very low carbon content.

543,289 AHLMANN, N. Production of pig-iron.

543,294 FALCONBRIDGE NICKEL MINES, LIMITED. Electrolytic production of nickel.

543,319 BIRMINGHAM ALUMINIUM CASTING (1903) COMPANY, LIMITED, PRITCHARD, P., and TAYLOR, G. O. Furnace or cell for carrying out aluminium refining process.

543,362 BLACKBURN AIRCRAFT, LIMITED, and NIVISON, D. B. Production of bent tubes.

543,370 GENTIL, H. L., and ALLOY PROCESSES, LIMITED. Metallurgic furnaces.

543,374 METCALFE, H. Means for supplying heated air to furnace and the like fires.

543,383 THORNTON, A. A. (Cleveland Graphite Bronze Company). Method of and apparatus for making composite metal strip.

543,399 GENTIL, H. L., and ALLOY PROCESSES, LIMITED. Reduction of magnesium.

543,431 GENTIL, H. L., and ALLOY PROCESSES, LIMITED. Purification of aluminium.

543,468 GENTIL, H. L., and ALLOY PROCESSES, LIMITED. Reduction of aluminium and like metals.

543,469 BALDWINS, LIMITED, and DAVIES, H. L. Machines for use in examining or assorting metallic or other plates or sheets, and particularly tinplates.

543,494 WALLIS, C. P., and QUICK, T. A. Roll-bending machines for bending angle and similar section bars.

543,495 GREENAWALT, J. E. Method or process of agglomerating and decarbonising cast-iron and steel borings, turnings, and the like by means of sintering.

543,577 PARLANTI, C. A., and BOWEN, E. WINDSOR. Casting of non-ferrous metals.

543,610 ALUMINIUM COMPANY OF AMERICA. Formation of hollow metallic propeller blades for aircraft.

543,627 PRESSED STEEL COMPANY, LIMITED, and MURRAY, G. Method for the protection of steel containers against corrosion.

543,652 ABBEY, A. (Dow Chemical Company). Production of metallic magnesium.

543,656 MOND NICKEL COMPANY, LIMITED. Nickel-iron-chromium alloys.

543,708 RUBEN, S. Method of producing a conductive metal coating upon a non-conductive object, and objects formed thereby.